NEWARK BAY STUDY AREA
REMEDIAL INVESTIGATION WORK PLAN

SEDIMENT SAMPLING
AND SOURCE IDENTIFICATION PROGRAM
NEWARK BAY, NEW JERSEY

Volume 2a of 3

Investigation Work Plan
Sampling and Analysis Plan
Site Management Plan
Quality Assurance Project Plan

Text, Tables, and Figures

Revision 1
September 2005

Submitted by

Tierra Solutions, Inc.
East Brunswick, NJ

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Foreword

The Newark Bay Study Area Remedial Investigation Work Plan (RIWP) has been developed in accordance with Paragraph 39 of the Administrative Order on Consent Index No. CERCLA 02-2004-2010 (AOC), and is segregated into three volumes:

- ***Volume 1 (2004): Inventory and Overview Report of Historical Data (herein referred to as the Inventory Report)*** (one DVD)*
    - 1a: Text/Appendices
    - 1b: Tables
    - 1c: Figures

- ***Volume 2 (2005): Investigation Work Plan (IWP)/Sampling and Analysis Plan (SAP)/Site Management Plan (SMP)/Quality Assurance Project Plan (QAPP) (herein referred to as the IWP)*** (two binders total)
    - 2a: Text/Tables/Figures
    - 2b: Appendices

- ***Volume 3 (2005): Health and Safety/Contingency Plan (herein referred to as the HASCP)*** (one binder total)

*The June 2004 version (Revision 0) of the Inventory Report has not changed, and is therefore being provided in electronic format only for the sake of completeness.

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Acronyms and Abbreviations

^{137}Cs	Cesium-137
^{210}Pb	Lead-210
^{7}Be	Beryllium-7
AOC	Administrative Order on Consent
BAZ	biologically active zone
BBL	Blasland, Bouck & Lee, Inc.
°C	degrees Celsius
CAF	corrective action form
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFS	cubic feet per second
CLP	contract laboratory program
cm	centimeters
COPC	chemicals of potential concern
CSM	conceptual site model
CSO	combined sewer overflows
CVAA	cold vapor atomic absorption
cy	cubic yard
DDT	dichlorodiphenyl-trichloroethate
DGPS	Differential Global Positioning System
DQO	data quality objectives
EDS	Environmental Data Services, Ltd.
EMPC	estimated maximum possible concentration
°F	degrees Fahrenheit
FC	Facility Coordinator
FS	Feasibility Study
FSWP	Feasibility Study Work Plan
ft	feet
ft^2	square feet
ft^3	cubic feet
GC/MS	gas chromatography/mass spectrometry
HASCP	Health and Safety Contingency Plan
HRGC/HRMS	high resolution gas chromatography/high resolution mass spectrometry
ICP	inductively coupled plasma emission spectroscopy
IDC	initial demonstration of capability
IDL	instrument detection limit
in/yr	inches per year
IWP	Investigation Work Plan
LPRRP	Lower Passaic River Restoration Project
LCS	laboratory control samples
m	meters
m^3	cubic meters
MDL	method detection limit
MLW	mean low water
MLLW	mean lower low water

mm/yr	millimeters per year
MS	matrix spike or mass spectrometer
MS/Duplicate	matrix spike/duplicate
MS/MSD	matrix spike/matrix spike duplicate
NAD	North American Datum
NAVD	North American Vertical Datum
NCP	National Contingency Plan
NJDEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NY/NJ	New York/New Jersey
OPR	ongoing precision and recovery
OSHA	Occupational Safety & Health Administration
OSI	Ocean Surveys, Inc.
PAH	polycyclic aromatic hydrocarbons
PA NY/NJ	Port Authority of New York and New Jersey
ΣPCB	sum of all PCB congeners
PCB	polychlorinated biphenyls
PCDD	polychlorinated dibenzo-p-dioxins
PCDF	polychlorinated dibenzofurans
PE	performance evaluation
pg/L	picograms per liter
PM	Project Manager
POTW	publicly owned treatment works
ppm	parts per million
ppth	parts per thousand
ppt	part per trillion
PVSC	Passaic Valley Sewerage Commissioners
QA	quality assurance
QAC	Quality Assurance Contractor
QA/QC	quality assurance/quality control
QAO	Project Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	quality control
%R	percent recovery
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RIWP	Remedial Investigation Work Plan
RPD	relative percent difference
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SDG	sample delivery group
SI	Sediment Investigation
SICP	selected ion current profiles
SMP	Site Management Plan
SOP	standard operating procedure
SPI	Sediment Profile Image
SOW	Statement of Work

SQL	sample quantitation limit
SRM	Standard Reference Materials
SVOC	semi-volatile organic compound
SWO	storm water outfall
TAL	target analyte list
TBD	to be determined
the Bay	Newark Bay
Tierra	Tierra Solutions, Inc.
TIG	The Intelligence Group, LLC
TOC	total organic carbon
TEPH	total extractable petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VER	verification standards
VOC	volatile organic compound
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
2,3,7,8-TCDF	2,3,7,8-tetrachlorodibenzo-p-furan

Executive Summary

The Newark Bay Study Area Remedial Investigation Work Plan (RIWP) has been developed in accordance with Paragraph 39 of the Administrative Order on Consent Index No. CERCLA 02-2004-2010 (AOC), and consists of three primary components: the Inventory and Overview Report of Historical Data (Volume 1), the Investigation Work Plan (Volume 2), and the Health and Safety/Contingency Plan (Volume 3). Tierra Solutions, Inc. (Tierra), on behalf of Occidental Chemical Corporation (formerly known as Diamond Alkali Company), is undertaking a Remedial Investigation/Feasibility Study (RI/FS) for the Newark Bay Study Area in accordance with the terms and provisions of the AOC.

Introduction

Newark Bay Study Area sediments are known to contain numerous chemicals of potential concern (COPCs); however, more specific information is needed to develop a complete understanding of the extent of COPCs and their associated impact. To help frame this assessment, three RI-related goals are established in the AOC:

- ***RI Goal 1***: Determine the horizontal and vertical distribution and concentration of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), pesticides, and metals for the Newark Bay Study Area sediments (AOC Scope of Work [SOW] Section A.1);

- ***RI Goal 2***: Determine the primary human and ecological receptors (endpoints) of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals contaminated sediments in the Newark Bay Study Area (SOW Section A.2); and

- ***RI Goal 3***: Determine the significant direct and indirect continuing sources of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals to the sediments in the Newark Bay Study Area (SOW Section A.3).

(Note: the list of media/analytes shown above reflect that which is stated in the AOC. As indicated throughout this Work Plan, Tierra will, at a minimum, meet these requirements, and at times provide for additional collection and/or analyses, as appropriate.)

This volume (Volume 2) of the RIWP contains the Investigation Work Plan, or IWP, which describes the efforts required to address RI Goal 1, and a portion of RI Goals 2 and 3. The content and format of this document reflects AOC requirements, along with those associated with the U.S. Environmental Protection Agency's (USEPA) Requirements for Quality Assurance Project Plans (QA/R5 Guidance) (USEPA, 2001a). This combined approach allowed four of the five requisite AOC plan elements to be merged together as one document, including:

- the IWP;
- the Sampling and Analysis Plan (SAP);
- the Site Management Plan (SMP); and
- the Quality Assurance Project Plan (QAPP).

The Health and Safety/Contingency Plan (HASCP), which represents the fifth plan element, is provided as RIWP Volume 3.

Overall Remedial Investigation Approach

RI Goal 1

A sampling program has been developed to meet RI Goal 1 - to obtain data to characterize the horizontal and vertical distribution of COPCs in sediments. Given Newark Bay's highly complex setting and the paucity of historical sediment data, this sampling program will be implemented in a phased manner. Specifically, this program will consist of the following:

- Initial Phase - Phase I Sediment Investigation (SI)
- Subsequent Phase - Phase II SI

This IWP focuses on the implementation of the Phase I SI Program, which is to be conducted in an area of Newark Bay bounded by the following landmarks:

- the Lower Passaic River Restoration Project (LPRRP) downstream boundary;
- the Conrail Bridge at the Hackensack River;
- the Bayonne Bridge; and
- the Goethals Bridge.

It is important to note that these boundaries are for Phase I work only, and could be modified for any future sampling activities.

The area from which sediments will be collected will be referred to as the Phase I SI Study Area, and the Sample Processing Area will be used to process the sediments for shipment to the appropriate laboratories (Figure 1-2). Both the Phase I SI Study Area and the Sample Processing Area are considered to be part of the Site.

The Source Identification Program (as further described herein) will be conducted within the Phase I SI Study Area, but will also extend into the major tributaries described in this section (i.e., Passaic River, Hackensack River, Arthur Kill, and Kill van Kull), including smaller direct and indirect tributaries. In addition, certain upland areas surrounding Newark Bay will be subject to this work, depending on their relevance as areas of potential continuing sources. For purposes of Phase I, select source identification samples will be collected from Newark Bay and portions of the Hackensack River.

The Phase II SI Program will be developed once the Phase I data are collected and assessed.

RI Goal 2

USEPA is responsible for meeting RI Goal 2, which includes performing a Human and Ecological Risk Assessment. In doing so, USEPA will develop a Risk Assessment Plan, and Tierra will be responsible for collecting the data required by the Plan. Although the schedule and scope for developing the Risk Assessment Plan are not currently known, a limited amount of the data collected as part of the Phase I SI will be appropriate for use in the Risk Assessment.

RI Goal 3

USEPA will also be responsible for meeting RI Goal 3 by modeling the fate and bioaccumulation of COPCs for the Newark Bay Study Area (SOW Section B.3.b.iii). This work will consist of two discrete tasks – development of a Modeling Plan and characterization of storm water and Combined Sewer Overflows (CSOs) into the Newark Bay Study Area. USEPA will develop the Modeling Plan, and Tierra will be responsible for collecting the data required by the Plan. Because the schedule and scope for developing the Plan are not currently known, it is not addressed in this IWP.

The Source Characterization Program is Tierra's responsibility, and will be conducted in a phased manner, according to the following:

- Initial Phase - Source Identification Program
- Subsequent Phase - Source Sampling Program

Only the Source Identification Program is addressed in detail in this IWP; the information from which will be used to develop the subsequent Source Sampling Program.

Future RI Activities

Because the three AOC RI-related goals cannot be fully addressed at this time, additional planning information will be provided at a later date (as addenda to this IWP or otherwise, as appropriate) to incorporate data collection activities for the following:

- RI Goal 1: Tierra's Phase II SI Program;
- RI Goal 2: USEPA's Risk Assessment Plan; and
- RI Goal 3: USEPA's Modeling Plan and Tierra's Source Sampling Program.

Preliminary Conceptual Site Model

A comprehensive sediment data set is not currently available for Newark Bay; however, enough information is available to develop a preliminary conceptual site model (CSM). The preliminary CSM described in Section 3 of this IWP is based on (among other things) geomorphic features, historical and ongoing dredging, sedimentation processes, and the distribution of COPCs in sediments. The preliminary CSM and additional supporting information were used to design the Phase I SI that will be implemented to primarily achieve RI Goal 1.

The dominant geomorphic features of Newark Bay include the Federal Navigation Channels, the Port Channels, and the broad Sub-tidal Flats between the channels and the shorelines. Together, these areas cover approximately 82% of the Phase I SI Study Area (30% – Navigation and Port Channels, 52% – Sub-tidal Flats). Other geomorphic features include the Transitional Slopes located between the Channels and Sub-tidal Flats, Inter-tidal Areas, Industrial Waterfront Areas, and the Newark Bay Confined Disposal Facility (CDF).

Although the remaining Inter-tidal Areas represent a fraction of the wetlands that historically existed in the area, what is left does provide potential habitat for birds and other wildlife. In addition, the Industrial Waterfront Areas represent locations along the Newark Bay shoreline that have been extensively developed, and numerous continuing sources are likely present through various pathways (e.g., CSOs, storm water outfalls [SWOs], etc.). The Newark Bay CDF, located adjacent to the Port Channels, is still in operation.

Due to the variety of features, the circulation patterns in Newark Bay are complex and variable, and overall, the area serves as a net sink for sediments delivered from the watershed and by tidal transport. Dredging activities designed to deepen and widen the Navigation and Port Channels have modified or eliminated the historical sediment deposition record. The depths of the Navigation Channels – varying from 35 to 50 feet – are unique in Newark Bay and, as a result, these areas are more likely to accumulate sediments than other parts of the Bay. In contrast, the Sub-tidal Flats appear to be characterized by low sedimentation rates. The Transitional Slopes may serve principally as storage areas for sediments, although wind, waves, and currents from the tide and boat traffic in Newark Bay likely result in an ongoing redistribution in these areas.

Historical information regarding the distribution of COPCs throughout Newark Bay is somewhat limited, although data suggest that for some metals and organic chemicals, large-scale concentration differences exist between the southern and northern portions of the Bay. Also, the Port Channels appear to contain localized sources for several chemical classes. Data gathered to date have been primarily from surface sediment grab samples, so very little is understood about the presence of COPCs at depth. The Phase I SI Program, briefly described below, is designed to preliminarily address the gaps in the data set to enhance the understanding of the distribution of COPCs in Newark Bay, particularly the Phase I SI Study Area.

Phase I SI Program

Limited data currently exist to design and conduct a complete assessment of the Bay. Therefore, the sampling effort outlined in this IWP will be conducted in two phases. Data collected during the first phase (Phase I SI) will be combined with historical data to design the subsequent phase (Phase II SI).

The Phase I SI Program presented herein has been designed primarily to obtain data to characterize the horizontal and vertical distribution of COPCs in sediments (RI Goal 1), however, RI Goals 2 and 3 will also be addressed on a limited basis. The data collected will be used, amongst other things, to identify hot spots, assist in determining the concentrations of COPCs that may accumulate in the food chain and evaluate a range of possible remedial options for the Phase I SI Study Area. According to the AOC, this program is to be designed to obtain data to the 1940 sediment horizon.

Samples obtained as part of the Phase I SI effort will be gathered from the Navigation and Port Channels, Sub-tidal Flats, Transitional Slopes, Inter-tidal Areas, and Industrial Waterfront Areas. The primary objectives (pertaining primarily to RI Goal 1) of the Phase I SI are to:

- support further development of the preliminary CSM, and verify that the geomorphic areas used for sampling are appropriate for future programs;
- estimate the approximate depth of a critical "horizon" in the sediment bed (i.e., a layer in the sediment bed that can be associated with a particular year, in this case 1940);
- better understand broad patterns of constituents in both the surface and subsurface sediments, and attempt to preliminarily identify "hot spots" through statistical analyses (e.g., Rosner's test [USEPA, 2000b]);
- confirm that the current analytical chemistry and radiochemistry suite is appropriate for future testing; and
- determine data needs for Phase II.

For purposes of the Risk Assessment Program (RI Goal 2), a portion of the Phase I SI will focus on Inter-tidal Areas. The objectives of this work will be to:

- Preliminarily characterize (through sediment sampling) the nature of contamination within select ecologically sensitive Inter-tidal mudflats.

- Determine the depth of the biologically active zone (BAZ) within various geomorphic areas of the Phase I Study Area.

A more complete Risk Assessment Program will be implemented in the future based upon the development of USEPA's Risk Assessment Plan.

Finally, the Phase I SI will begin to address RI Goal 3 - determining significant direct and indirect continuing sources of COPCs to Newark Bay. As described in the AOC, this goal is comprised of two tasks. Under the first task, USEPA will be responsible for the development of a Modeling Plan which addresses the fate and bioaccumulation of COPCs. Tierra will be responsible for implementing the field data collection to support that plan.

Tierra proposes to proceed with the second task by implementing a phased program. Tierra's initial effort, the Source Identification Program, will consist of a search of publicly available documents and field reconnaissance, the results of which will be used to evaluate and rank significant, continuing sources. In addition, several sediment cores will be collected as part of the Phase I SI to assess potential impacts to the Bay from select historical and/or on-going sources.

Following an assessment of this information, Tierra will develop a Source Sampling Work Plan, which will describe a field sampling program focused upon completing the second task of RI Goal 3. This will likely include the characterization of stormwater and CSO discharges, along with the collection of additional sediment cores in areas believed to be impacted by localized sources. However, it is important to recognize that, according to the AOC, CSO collection procedures are to be consistent with the LPRRP work activities. Because this phase of the LPRRP is still under development, the actual scope and implementation schedule of the Source Sampling Work Plan are indeterminate at this time.

The entire data quality objectives (DQO) process, which better defines the program's objectives and resulting work, is presented in Section 4.1.

To meet the goals identified above, sediment samples will be collected from throughout the Phase I SI Study Area and analyzed for a broad range of chemicals. In addition, radiochemistry data will be collected, where appropriate. The chemical and radiochemical portions of the Phase I SI Program are summarized below.

Phase I SI Analytical Summary

Number of Sample Locations	Maximum Number of Samples[a]	Analytes
Chemical Analyses		
69 locations within seven geomorphic areas	317	Congener PCBs, Aroclor PCBs, pesticides, TEPHs, SVOCs, chlorinated herbicides, organotins, metals, cyanide, mercury, titanium, VOCs, PCDDs/PCDFs, TOC, Moisture Content, grain size[b], bulk density[b]
Radiochemistry Analyses		
51 locations within five geomorphic areas	460	Lead-210, Beryllium-7[e], Cesium-137[d]

Notes:
a. Does not include quality assurance/quality control samples.
b. Only conducted for select segments within each core.
c. Bulk density of the core will be assessed in the field.
d. Beryllium-7 will only be analyzed at the surface.
e. Cesium-137 samples will be collected in four of the five targeted geomorphic areas.
PCBs = polychlorinated biphenyls
TEPH = total extractable petroleum hydrocarbons
SVOCs = semi-volatile organic compounds
VOCs = volatile organic compounds
PCDDs/PCDFs = polychlorinated dibenzo-p-dioxins/ polychlorinated dibenzofurans
TOC = total organic carbon

In addition, a BAZ investigation (consisting of sediment profile images [SPI] and sediment grab samples) will be performed to determine the depth of benthic invertebrate activity within the surficial sediments of Newark Bay. A bathymetric survey will also be conducted during the Phase I SI Program to further develop the preliminary CSM, enhance the understanding of Phase I SI Study Area, and assist the field crew in implementing the field work.

Utilizing the more robust data set resulting from the Phase I SI work, the Phase II SI effort will be designed to more completely assess the presence and distribution of COPCs throughout the Newark Bay sediments, confirm the locations of any hot spots, and gather adequate information to further develop and evaluate remedial options.

RI Schedule

Tierra will initiate the two primary efforts described in this IWP – the Phase I SI Program and the Source Identification Program - following regulatory approval of this RIWP. Subsequent work activities, including the Phase II SI and the Source Sampling Programs, will follow. However, because the timing and scope of such significant work activities are dependent on the results of the initial work (along with that associated with the LPRRP), a definitive schedule for these later components cannot be presented at this time. Similarly, since the scope and timing for USEPA's development of the Risk Assessment Plan and the Modeling Plan are not known, schedules for these activities cannot be presented.

Data produced from each of the programs identified above are critical in the development of the Newark Bay RI Report. Since the timing for several activities is currently undefined, it is not yet possible to project an overall schedule for submitting the RI Report.

1. Introduction

This work plan has been developed to guide the Sediment Sampling and Source Identification Program for the Newark Bay Study Area (as defined herein), and has been prepared pursuant to Paragraph 39 of the Administrative Order on Consent Index No. CERCLA 02-2004-2010 (AOC) for Tierra Solutions, Inc. (Tierra), on behalf of Occidental Chemical Corporation (the successor to Diamond Shamrock Chemicals Company [formerly known as Diamond Alkali Company]). Tierra is undertaking a Remedial Investigation/Feasibility Study (RI/FS) for the Newark Bay Study Area in accordance with the provisions of the AOC.

This document represents Volume 2 of 3 of the Newark Bay Study Area Remedial Investigation Work Plan (RIWP), and shall herein be referred to as the Investigation Work Plan (IWP). The technical content of the IWP was designed in accordance with Appendix 1 (Statement of Work [SOW]) Section B.3.b through B.3.e of the AOC. The IWP was also designed in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the National Contingency Plan (NCP), including (without limitation) the following guidance documents issued by the U.S. Environmental Protection Agency (USEPA):

- *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (USEPA, 2002a);
- *Guidance on Choosing a Sampling Design for Environmental Data Collection* (USEPA, 2002b);
- *USEPA Requirements for Quality Assurance Project Plans* (QA/R-5 Guidance) (USEPA, 2001a); and
- *Data Quality Objectives Process for Hazardous Waste Site Investigations (QA/G-4HW)* (USEPA, 2000a).

Newark Bay, part of the New York/New Jersey (NY/NJ) Harbor Estuary, is located at the confluence of the Passaic and Hackensack Rivers, between the shores of Newark and Elizabeth to the west, Jersey City and Bayonne to the east, and Staten Island to the south. Newark Bay is linked to Upper New York Bay by the Kill van Kull, and to Raritan Bay by the Arthur Kill (Figure 1-1). Newark Bay is approximately six miles long and one mile wide.

1.1 Remedial Investigation Approach

As described in the AOC, Newark Bay Study Area sediments are known to contain various chemicals including (without limitation): polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), pesticides, and metals. To assess these chemicals of potential concern (COPCs), the AOC identifies three RI-related goals:

- *RI Goal 1*: Determine the horizontal and vertical distribution and concentration of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals for the Newark Bay Study Area sediments (SOW Section A.1);

- *RI Goal 2*: Determine the primary human and ecological receptors (endpoints) of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals contaminated sediments in the Newark Bay Study Area (SOW Section A.2); and

- *RI Goal 3*: Determine the significant direct and indirect continuing sources of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals to the sediments in the Newark Bay Study Area (SOW Section A.3).

(Note: As further described herein, Tierra will, at minimum, meet these goals, and at times, provide for additional collection and/or analyses, as appropriate).

The general approach which is to be followed in addressing each goal is discussed below. For clarification purposes, the area in which the IWP is to be conducted will be referred to as the "Site." The Site includes various non-contiguous areas within which work will be implemented, depending upon the particular program that is being performed.

1.1.1 RI Goal 1

For the purpose of addressing RI Goal 1, this IWP presents a sampling program that will primarily be used to characterize the "spatial distribution and concentration" of COPCs in sediments (SOW Section B.3.b.i). As described in greater detail in the following sections, this work will be conducted in a phased manner given Newark Bay's highly complex setting and the paucity of historical sediment data that appears to exist. This phased approach is designed to satisfy the testing and re-evaluation concept that is encouraged in USEPA's *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (USEPA, 2002a). Specifically, the sampling program will consist of the following:

- Initial Phase - Phase I Sediment Investigation (SI)
- Subsequent Phase - Phase II SI

As described throughout, the Phase I SI will also produce data that will assist in addressing RI Goals 2 and 3.

This IWP focuses on the implementation of the Phase I SI Program, which is to be conducted in an area of Newark Bay bounded by the following landmarks (Figure 1-2):

- the Lower Passaic River Restoration Project (LPRRP) downstream boundary;
- the Conrail Bridge at the Hackensack River;
- the Bayonne Bridge; and
- the Goethals Bridge.

The area from which sediments will be collected will be referred to as the Phase I SI Study Area, and the Sample Processing Area will be used to process the sediments for shipment to the appropriate laboratories (Figure 1-2). Both the Phase I SI Study Area and the Sample Processing Area are considered to be part of the Site. As described further in Section 1.1.3, the Site also includes Newark Bay tributaries for purposes of assessing potential sources.

The Phase II SI Program will be developed once the initial data are collected and assessed.

1.1.2 RI Goal 2

According to SOW Section B.3.b.ii, USEPA will be responsible for meeting RI Goal 2, which includes performing a Human and Ecological Risk Assessment. In doing so, USEPA will develop a Risk Assessment Plan, and Tierra will be responsible for collecting the data required by the Plan. Because development of the Risk Assessment Plan is not yet complete, only a limited amount of risk-based data will be collected as part of the Phase I SI Program.

1.1.3 RI Goal 3

For purposes of RI Goal 3 (SOW Section B.3.b.iii), USEPA will "perform modeling of the fate and bioaccumulation of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals for the Newark Bay Study Area as part of the Lower Passaic River Restoration Project." This work is to consist of two elements, as follows:

- USEPA will develop a Modeling Plan which is to define the data requirements for the above-referenced model, including (without limitation) water quality, sediment, and biota parameters. Once the Modeling

Plan is finalized, Tierra will be responsible for the associated data collection activities. However, because development of the Modeling Plan is not yet complete, this portion of RI Goal 3 is not addressed in this IWP.

- Tierra will characterize continuing storm water and combined sewer overflows (CSOs) into the Newark Bay Study Area consistent with the activities being conducted for the LPRRP. This second element involves the identification and assessment of (without limitation) Publicly-Owned Treatment Works (POTWs), CSOs, National Pollutant Discharge Elimination System (NPDES)-permitted discharges, storm water outfalls (SWOs), and various Newark Bay tributaries. This task will be conducted incrementally, according to the following:

    - Initial Phase - Source Identification Program
    - Subsequent Phase - Source Sampling Program

Only the Source Identification Program is addressed in detail in this IWP. This work will be performed within Newark Bay and its tributaries (including associated pathways), all of which are considered to be part of the Site. As part of this initial effort, a limited number of sediment cores will also be collected during the Phase I SI from select potential sources to the Bay.

1.1.4 Future RI Activities

Because the three RI goals cannot be fully addressed at this time, additional planning information will be provided at a later date (as addenda to this IWP or otherwise, as appropriate) to incorporate data collection activities for the following:

- RI Goal 1: Tierra's Phase II SI Program;
- RI Goal 2: USEPA's Risk Assessment Plan; and
- RI Goal 3: USEPA's Modeling Plan and Tierra's Source Sampling Program.

Changes to this IWP that are necessary and appropriate to complete these sampling programs will be submitted to USEPA for approval in accordance with Paragraph 89 of the AOC.

1.2 IWP Organization

This IWP incorporates four of the five individual plan elements required in Section B.3 of the SOW, including the following:

- IWP - describes how the proposed work activities will each contribute to achieving the three RI goals outlined in the AOC;
- Sampling and Analysis Plan (SAP) - describes in greater detail the planned sample collection and analytical protocols;
- Site Management Plan (SMP) - identifies the major contractors and subcontractors who will perform the work; and
- Quality Assurance Project Plan (QAPP) - describes the measures to be taken to provide quality assurance (QA) and maintain quality control (QC) during the work.

Taken together, these plan elements cover the proposed field work, from program design to data management and control. The fifth plan element, which includes the Health and Safety/Contingency Plan (HASCP), is provided as Volume 3 of the RIWP.

While meeting the necessary requirements of the AOC, this IWP has generally been structured in accordance with USEPA's QA/R-5 Guidance (USEPA, 2001a). This guidance provides a tool for documenting the type and quality of data needed to make informed environmental decisions, and serves to integrate the technical and quality aspects of a typical RI (including planning, implementation, assessment, reporting, and quality improvement). Integrating elements of the QA/R-5 Guidance with the four AOC plan elements outlined above also provides a streamlined work plan structure.

To confirm that the required QA/R-5 elements have been accounted for, Table 1-1 provides a cross-reference between the QA/R-5 elements and the contents of this IWP. Table 1-2 presents the required AOC elements, also cross referenced to the IWP.

2. Newark Bay Description

This section of the IWP provides a brief overview of Newark Bay's physical setting and characteristics. Also provided is a summary of the Bay's historic and current usage, including a brief description of past, current, and planned dredging activities.

2.1 Physical Setting

Newark Bay, part of the NY/NJ Harbor Estuary, is located at the confluence of the Passaic and Hackensack Rivers, between the shores of Newark and Elizabeth to the west, Jersey City and Bayonne to the east, and Staten Island to the south. Newark Bay is linked to Upper New York Bay by the Kill van Kull, and to Raritan Bay by the Arthur Kill (Figure 1-1). The line between Union-Essex Counties on the west and Hudson County on the east extends down the middle of the Bay. The line between Union County and Essex County roughly aligns with the Elizabeth Channel, which separates Port Elizabeth from Port Newark (U.S. Army Corps of Engineers [USACE], 1997a) (Figure 1-1).

Newark Bay is approximately six miles long and one mile wide. With the exception of the navigation channels, turning basins, and docking facilities, Newark Bay is a very shallow water body (USACE, 1997a). The greatest single extent of "shallow water" area (0.5 to 10 feet [ft] below mean low water [MLW]) is located on the east side, with smaller shallow water areas located along the west side above and below Port Newark Channel, south of Kearny Point, and south of the South Elizabeth Channel (USACE, 1997a).

The navigation channels provide access to the port facilities located on the western side of the Bay. These federally-maintained channels have authorized widths ranging from 500 to 2,200 ft, and depths between 35 and 50 ft below MLW. In 2004, the USACE began implementing plans for the New York and New Jersey Harbor Navigation Project and the Harbor Deepening Project, which seeks to perform additional dredging in the New York and New Jersey Harbor including Newark Bay. These plans are designed to allow more modern, deeper draft marine cargo vessels access to the Bayonne, Elizabeth, Newark, and New York Ports (USACE, 2004a). Additional detail regarding future USACE dredging activities is provided in Section 2.2.4.3 of this IWP.

2.1.1 Newark Bay Study Area Boundaries

As described in AOC Paragraph 2.r, the Newark Bay Study Area includes Newark Bay and portions of the Hackensack River, the Arthur Kill, and the Kill van Kull. However, more definition is required for designing and implementing this IWP. Provided below is an explanation of the specific geographic borders for the work, followed by a listing of these specific boundaries.

2.1.1.1 Phase I SI Program

The Hackensack River, Passaic River, Arthur Kill, and Kill van Kull represent major tributaries to Newark Bay, and according to data presented in RIWP Volume 1 (Tierra, 2004), may act as significant sources of sediment and COPCs to the Bay. The shorelines of the Bay, Arthur Kill, and Kill van Kull are highly developed with numerous industrial, commercial, and marine facilities. POTWs, CSOs, NPDES-permitted discharges, SWOs, and direct runoff represent myriad potential up-stream and upland sources of chemicals that may be discharged into each waterway. Based upon concentration patterns in southern Newark Bay, previous investigations have concluded that contributions of sediments and chemicals emanate from the Arthur Kill and the Kill van Kull (National Oceanic and Atmospheric Administration [NOAA], 1984). This finding is supported by a recent evaluation of sediment transport at Newark Bay's confluence with each of the Kills (Styles et al., 2001; Haldeman et al., 2002; Hunter et al., 2002).

NOAA evaluated sediment contaminants in the Bay and concluded that the highest concentrations of metals in surface sediments occurred near the mouths of the Passaic River, Hackensack River, and Arthur Kill, while the lowest concentrations were found in the middle of Newark Bay (NOAA, 1984). NOAA also concluded that these tributaries are major sources of metals to Newark Bay (NOAA, 1984). Similar to metals, the distribution of certain organic chemicals in surface sediments reflects higher concentrations in the southern (near the Arthur Kill) and northern (near the Passaic and Hackensack Rivers) parts of the Bay (Figures 3-6a through 3-6p of the RIWP Volume 1 [Tierra, 2004]). In fact, the highest sediment dichlorodiphenyl-trichloroethate (DDT) concentrations measured in the system occur in the Arthur Kill and southern Newark Bay, suggesting the possibility of either continuing or historical sources of DDT in these areas.

University researchers (Styles et al., 2001; Hunter et al., 2002) have recently collected data for evaluation of sediment transport in the Kills, and initial results that have been presented support earlier findings by

Suszkowski (1978) that both Kills contribute large amounts of sediment to the Bay through tidal and estuarine circulation transport processes. These researchers have collected transport data at the Goethals Bridge (spanning the Arthur Kill), at the Bayonne Bridge (which spans the Kill van Kull), and also at the head of Newark Bay near the confluence of the Passaic and Hackensack Rivers, among other locations.

Because one of the AOC-related RI goals is to investigate continuing direct and indirect sources of certain chemicals to Newark Bay (RI Goal 3), establishing study area boundaries where the tributaries meet the Bay provided a convenient mechanism to evaluate the aforementioned transport measurements. Through this, the available transport data can be used directly to assess such potential sources. Based on these considerations, the Newark Bay Study Area for the Phase I SI Program (i.e., Phase I SI Study Area) is defined to include Newark Bay extending to:

- the LPRRP downstream boundary;
- the Conrail Bridge at the Hackensack River;
- the Bayonne Bridge; and
- the Goethals Bridge.

As defined by USEPA (2005), the downstream boundary of LPRRP consists of an imaginary line drawn between two lights surrounded by riprap – one located in Essex County, NJ (latitude = 40.707725; longitude = 74.118945; designated as Fl [2+1] R 6s “NB”) and one located at Kearny Point in Kearny, NJ (latitude = 40.712119; longitude = 74.115651; designated as Fl G 2.5s “5”). For the purposes of the Phase I SI Program, this imaginary line was extended in a northeasterly and southwesterly direction, to the intersection of the respective shorelines.

Figure 1-2 illustrates the Phase I SI Study Area boundaries described above, which encompasses a total area of approximately 6.6 square miles. These boundaries will be reevaluated using the results of the Phase I SI prior to conducting any future sampling activities.

The Source Identification Program (RI Goal 3) will be conducted within the Phase I SI Study Area, but will also extend into the major tributaries described in this section (i.e., Passaic River, Hackensack River, Arthur Kill, and Kill van Kull), including smaller indirect tributaries. In addition, upland areas surrounding Newark Bay will be subject to this work, depending on their relevance as a potential continuing source.

As indicated previously, sediments collected from the Phase SI Study Area will be processed at the Sample Processing Area, as shown on Figure 1-2.

2.1.2 Navigation Channel Reach Descriptions

As shown in Figure 1-2, Newark Bay encompasses 11 USACE-defined navigation reaches, including (from south to north): 1) Gulfport Reach, 2) Elizabethport Reach, 3) North of Shooters Island Reach, 4) South of Shooters Island Reach, 5) Bergen Point West Reach, 6) Newark Bay South Reach, 7) Newark Bay Middle Reach, 8) Newark Bay North Reach, 9) Turning Basin, 10) Kearny Point Reach, and 11) Droyers Point Reach (USACE, 1997a). In addition to these 11 reaches, the Bay contains three main port channels: Port Newark Channel, Elizabeth Channel, and South Elizabeth Channel. There are also minor channels, including the Port Elizabeth Pierhead Channel, Port Elizabeth Inshore Channel, Port Elizabeth Branch Channel, Port Newark Inshore Channel, and Port Newark Branch Channel (USACE, 1997a).

A brief description of each USACE reach located within Newark Bay is provided below. Table 2-1 provides additional information to supplement this discussion. For the geographical location of each reach, refer to Figure 1-2.

<u>Gulfport Reach</u>

The portion of the Gulfport Reach within the Phase I SI Study Area extends approximately 1,200 ft from Goethals Bridge to the beginning of the Elizabethport Reach. The navigation channel is approximately 500 ft wide, and was last maintained to a depth of 35 ft below MLW in 1997 (Figure 1-2). As part of the Arthur Kill/Howland Hook Marine Terminal Federal Navigation Project, this reach is currently being dredged to 41 ft below MLW.

<u>Elizabethport Reach</u>

The Elizabethport Reach extends from the Gulfport Reach (just north of the Goethals Bridge) to its junction with the North of Shooters Island Reach (approximately 6,700 ft). The Elizabethport Reach is bounded to the west by the City of Elizabeth and the Howland Hook/Port Ivory section of Staten Island to the east (Figure 1-2). This reach was maintained at 35 ft below MLW, and is currently being dredged to 41 ft below MLW as part of the Arthur Kill/Howland Hook Marine Terminal Federal Navigation Project (Figure 2-1). It is proposed to be dredged to 50 ft below MLW in January 2009 as part of the New York and New Jersey Deepening Project (Figure 2-2).

North of Shooters Island Reach

The North of Shooters Island Reach is bordered by the City of Elizabeth to the northwest and the Port Ivory section of Staten Island to the south (Figure 1-2). The reach extends north of Shooters Island where it connects with the Newark Bay South Reach and Bergen Point West Reach; in addition, there is a junction with South of Shooters Island Reach at a point west of Shooters Island. The navigation channel is approximately 600 ft wide, 8,700 ft long, and is currently being dredged to 41 ft as part of the Arthur Kill/Howland Hook Marine Terminal Federal Navigation Project (Figure 2-1). As part of the New York and New Jersey Deepening Project, this reach is to be dredged to 50 ft below MLW in January 2008 (Figure 2-2).

South of Shooters Island Reach

The South of Shooters Island Reach extends approximately 6,400 ft from just west of Shooters Island to the Bergen Point West Reach, approximately one-half mile west of the Bayonne Bridge. Shooters Island and the North of Shooters Island Reach is north of this reach. The Mariners Harbor section of Staten Island is south of the reach, and is lined with numerous active and inactive piers (Figure 1-2). There are also some derelict piers that extend from the east and west sides of Shooters Island. The navigation channel is approximately 400 to 800 ft wide, and was last maintained to a depth of 35 ft below MLW in 1984 (Figure 2-1). There are currently no future dredging plans for this reach as part of the New York and New Jersey Harbor Deepening project.

Bergen Point West Reach

The Bergen Point West Reach connects with the North of Shooters Island Reach at the northeast corner of Shooters Island, and with the South of Shooters Island Reach to the east of Shooters Island (Figure 1-2). The reach extends past the Bayonne Bridge in the Kill van Kull, with approximately 4,500 ft within the Phase I SI Study Area. The Newark Bay South Reach and Bergen Point are north of this reach, while the Port Richmond section of Staten Island is south. The navigation channel is approximately 800 ft wide. In 2004, a portion of this reach was dredged to a new maintenance depth of 50 ft below MLW, while the remaining channel was dredged to 45 ft below MLW (Figures 2-1). In April 2005, the USACE resumed operations to deepen the remainder of the reach to 50 ft below MLW (Figure 2-2).

Newark Bay South Reach

The Newark Bay South Reach (South Reach) extends from just east of Shooters Island to halfway between the South Elizabeth Channel and Elizabeth Channel (approximately 1.5 miles) (Figure 1-2). The navigation channel runs relatively close to the Bayonne shore, where there are vacant land areas formerly occupied by bulk fuel and chemical storage terminals, as well as a few piers. The southern portion of the South Reach was dredged to 45 ft below MLW in 2004 (Figure 2-1). Additional dredging to 50 ft below MLW is scheduled to be performed in June 2009 as part of the New York and New Jersey Harbor Deepening Project (Figure 2-2).

Newark Bay Middle Reach

The Newark Bay Middle Reach (Middle Reach) stretches northward from the end of the South Reach for approximately 2.3 miles (Figure 1-2). This section of the channel is approximately 550 ft wide and is broken down into two sections: from the end of the South Reach, north to the Port Elizabeth Branch Channel; and from the Port Elizabeth Branch Channel, north to the Port Newark Branch Channel. The southern section of the Middle Reach is approximately 45 ft below MLW and the northern section of the Middle Reach is approximately 40 ft below MLW. The Middle Reach connects with the Port Newark Channel and Elizabeth Channel to the west (USACE, 1997a). The southern portion of the Middle Reach will be dredged in October 2005 as part of the New York and New Jersey Harbor Deepening Project (Figure 2-2).

At Port Newark, a Branch Channel (40 ft below MLW and 800 ft wide) leads inward to the Inshore Channel. Maintained at a depth of 40 ft below MLW and a width of 400 ft, the Inshore Channel runs perpendicular to the main navigation channel (Middle Reach) and provides access to the docks and piers of Port Newark. Port Newark Channel was last dredged in 2002. There are currently no future dredging plans for the Port Newark Channel as part of the New York and New Jersey Harbor Deepening Project, however, this channel will be maintenance dredged to 40 ft in October 2005.

Just south of the Port Newark Channel, running parallel to the main navigation channel, is the Port Newark Pierhead Channel. The Port Newark Pierhead Channel was last dredged to 40 ft below MLW in 2002 and is approximately 290 ft wide. There are currently no future plans to dredge the Port Newark Pierhead Channel as part of the New York and New Jersey Harbor Deepening Project, however this channel will be maintenance dredged to 40 ft in October 2005.

At Port Elizabeth, a similar channel (Elizabeth Channel) exists, along with a pierhead channel (Port Elizabeth Pierhead Channel) and a south channel (South Elizabeth Channel) (Figure 1-2). Elizabeth Channel consists of a Branch Channel and Inshore Channel, with both channels maintained at a depth of 45 ft below MLW and a width of approximately 400 ft (Figure 1-2). This channel is scheduled for maintenance dredging to 45 ft in October 2005. Additionally, berths within the Elizabeth Channel are continually dredged by the Port Authority of New York and New Jersey (PA NY/NJ).

Just south of the Elizabeth Channel is the Port Elizabeth Pierhead Channel. The Port Elizabeth Pierhead Channel is approximately 770 ft wide and runs between the east bulkhead and the main navigational channel (Middle Reach), with water depths maintained at approximately 45 ft below MLW (last maintained in 2004) (Figure 2-1). Immediately south of the Port Elizabeth Pierhead Channel is the South Elizabeth Channel. The South Elizabeth Channel is approximately 290 ft wide and runs 2,600 ft along the south bulkhead.

As part of the New York and New Jersey Harbor Deepening project, Elizabeth Channel, Port Elizabeth Pierhead Channel, and South Elizabeth Channel are slated to be dredged to 50 ft below MLW in April 2011, October 2005, and June 2009, respectively (Figure 2-2).

Newark Bay North Reach

The Newark Bay North Reach (North Reach) stretches northward approximately 1.5 miles from the northern boundary of the Middle Reach, maintaining a width of approximately 500 ft (Figure 1-2). It ends at the Turning Basin, located at the confluence of the Passaic and Hackensack Rivers. The project depth of the Newark Bay North Reach is 35 ft below MLW, and it was last dredged in 1989 (Figure 2-1; Table 2-2). There are currently no future dredging plans for this reach as part of the New York and New Jersey Harbor Deepening project.

Turning Basin

The Turning Basin is located in the northern portion of Newark Bay, with the North Reach to the south and Kearny Point and Droyers Point Reaches to the north (Figure 1-2). The Turning Basin is approximately 850 ft wide and 1,400 ft long. The project depth of the Turning Basin is 35 ft below MLW, and it was last dredged in 1989 (Figure 2-1). There are currently no future dredging plans for the Turning Basin as part of the New York and New Jersey Harbor Deepening project.

Kearny Point Reach

The Phase I SI Study Area ends approximately at the southern boundary of the Kearny Point Reach (Figure 1-2). The navigation channel within this reach (which measures approximately 300 ft wide and has a project depth of 30 ft below MLW) runs close to the Newark side of Newark Bay. Kearny Point Reach was last dredged in 1983 (Table 2-2), and there are currently no future dredging plans for this reach as part of the New York and New Jersey Harbor Deepening project.

Droyers Point Reach

The portion of Droyers Point Reach within the Phase I SI Study Area extends approximately 6,000 ft from the navigation light at the terminus of the Turning Basin, northeast to the mouth of the Hackensack River at the abandoned Conrail Bridge (Figure 1-2). The navigation channel within this reach is approximately 300 ft wide, with depths ranging between 22 and 25 ft below MLW. Droyers Point Reach was last dredged in 1986 (Table 2-2). There are currently no future dredging plans for this reach as part of the New York and New Jersey Harbor Deepening project.

2.1.3 Non-Channel Areas

Five major shallow water areas are located within Newark Bay, but outside of the navigation channel. A brief description of the location and approximate water depth of these areas are presented below.

Eastern Newark Bay

The largest shallow water area is located along the eastern side of Newark Bay with the North, Middle, and South Reaches to the west, and the City of Bayonne and Jersey City to the east (Figure 1-2). Water depths within this area range from 1 to 11 ft below MLW (USACE, 1997a).

Northern Newark Bay

A large shallow water area is located in the northern portion of Newark Bay south of Kearny Point (Figure 1-2). This area is bounded on the west by Kearny Point Reach and by Droyers Point Reach to the east. Water depths range from 1 to 4 ft below MLW (USACE, 1997a).

Western Newark Bay

A limited shallow water area is located along the western side of Newark Bay with Kearny Point Reach to the north, North Reach to the east, Port Newark Channel to the south, and Port Newark to the west (Figure 1-2). This area comprises Confined Disposal Facility (CDF) Area 2 (locations of originally proposed Cells 2S and 2N) (USACE, 1997a); however, based on information from the USACE and PA NY/NJ, these CDFs will not be constructed. Water depths in this area range from 1 to 9 ft below MLW (Figure 1-2) (USACE, 1997a).

Middle Newark Bay

A shallow water area is located in the mid-section of Newark Bay between the Port Newark Pierhead Channel and Middle Reach where water depth ranges between 1 and 5 ft below MLW (USACE, 1997a) (Figure 1-2). The Newark Bay CDF Area 1 (Cell 1S) is located within this shallow area. Cell 1S was constructed between June and November 1997. In February 1999, water depths within the CDF were reported at approximately 45 ft below the surrounding sediment surface at the edge of the cell (Matthew et al., 1999). In 2001, dredge materials from Lower Manhattan (dredged to accommodate barges for clean-up of the September 11, 2001 terrorist attacks) were placed in the Newark Bay CDF (USACE, 2001). More recently, dredge materials from the Arthur Kill 41/40 project that were found unacceptable for beneficial reuse as structural fill material at upland sites were deposited in the CDF (USACE, 2005a). The CDF continues to be in operation (USACE, 2005a).

Southwestern Newark Bay

An extensive shallow water area is located west of the South Reach, north of the North of Shooters Island Reach, south of South Elizabeth Channel, and east of the City of Elizabeth (Figure 1-2). This shallow area has water depths that range from 1 to 8 ft below MLW (USACE, 1997a).

2.1.4 Geologic Setting

Newark Bay is situated within the Newark Basin portion of the Piedmont physiographic province, which itself is located between the Atlantic Coastal Province and the Appalachian Province. The Newark Basin is underlain by sedimentary rocks (sandstones, shales, limy shales, and conglomerates), igneous rocks (basalt and diabase), and metamorphic rocks (schists and gneiss). These rocks are from the mid-Triassic to early Jurassic periods. Bedrock underlying the Bay consists of the Lockatong Formation (light to dark gray silty argillite and laminated mudstone that has been thermally metamorphosed to hornfels where intruded by diabase), Passaic Formation (interbedded red-brown sandstones and shales), and Jurassic diabase (dark gray to black, moderately fractured igneous rock [the Palisades]) (Nichols, 1968; NOAA, 1984; Drake et al., 1996).

Almost the entire Bay (including Passaic and Hackensack River Basins) was subjected to glacial erosion and deposition as a result of the last stage of the Wisconsin glaciation. Considerable quantities of stratified sand, silt, gravel, and clay were deposited in a glacial lake covering the area. These glaciofluvial deposits overlie bedrock and underlie the meadowlands, fill, and estuarine sediments.

The land surface surrounding Newark Bay has moderate relief, and consists of rounded and elongated hills within a central lowland valley bracketed by long volcanic ridges. This landscape is predominantly an expression of remnant features of Triassic volcanism and Pleistocene (Wisconsin-age) glaciation (Argon, 1980; Averill et al., 1980; USACE, 1997a). Most of the Bay is underlain by the Passaic Formation, but the westernmost edge is underlain by a sliver of the Lockatong Formation that was split by Jurassic intrusion of diabase (the Palisades) (Lyttle and Epstein, 1987; Drake et al., 1996). The bedrock surface beneath Newark Bay is highly irregular, having been shaped by preglacial and interglacial fluvial erosion and glacial scour, and contains numerous rock pinnacles and entrenched channels (Carswell, 1976; USACE, 1997a).

During Wisconsin-age glaciation, glacial outwash (sand and gravel mixtures) and glacial till (sand, silt, and clay with cobbles and boulders) were deposited on top of the bedrock surface, and now provide a mantle that varies in thickness, with the greatest depths in the incised bedrock valleys. These incised valleys were only partially filled by outwash and till, but were subsequently filled by lacustrine sediments (varved silts and clays) deposited in lakes that formed behind the terminal moraine left by the retreating glaciers (Carswell, 1976; Agron, 1980).

Lake Hackensack covered the area now occupied by the Hackensack River Basin and Newark Bay, whereas Lake Passaic covered much of the present day Passaic River Basin. These lakes existed for several thousand years, during which the lake basins accumulated sediments (Suszkowski, 1978).

The moraines were eventually overtopped by lake waters and breached. Glacial lakes Passaic and Hackensack then drained. The lake bottoms experienced some erosion, but also deposition of alluvium. Sea level rise occurring within the last several thousand years led to immersion of the Bay by saline water. Within the intertidal zone, salt marshes formed and created the extensive meadowlands environment of which some remnants remain today (Argon, 1980; Averill et al., 1980).

Within Newark Bay, Pleistocene sediments range in thickness from 30 to 45 ft outside of the navigation channel, and consist primarily of glacial outwash and till. The Pleistocene sediments are covered by layers of silt, clay, and organic matter deposited by streams and rivers that empty into the Bay. These black alluvial deposits are relatively thin layers that have a high degree of horizontal and vertical variability, representing recent estuarine sedimentation (USACE, 1997a).

Sediments found on the bottom or just below the bottom of Newark Bay are mostly fine-grained, within the range of silt and clay-sized particles (USACE, 1997a). The pattern of sediment types (sand/gravels versus silt/clays) is indicative of fluvial sediment input at the north end of the Bay, and tidal exchange sedimentation at the south end.

Coarser sediments are found at the north end of Newark Bay at the mouths of the Passaic and Hackensack Rivers. The central part of Newark Bay shows primarily deposition of sandy silts and clays that change to silty clays and silty sands at the outlets to the Arthur Kill and Kill van Kull. The coarser sediments found at the southern end of Newark Bay have been attributed to the scouring effect of tidal currents (USACE, 1997a).

2.1.5 Surface Water Hydrology

Newark Bay is the receiving water body for the Passaic and Hackensack Rivers. According to Suszkowski (1978), it is a partially mixed estuary, meaning that there is some density stratification of saline and fresh water. The Passaic River discharges approximately 650,000 gallons per minute (or 1,448 cubic feet per second [cfs]) of fresh water into the Bay, while the Hackensack River adds an additional 87,000 gallons per minute (or 194 cfs) (NOAA, 1984). Some density stratification occurs in Newark Bay such that a wedge of salt water has been detected at the base of the navigation channels as far north as the mouth of the Hackensack River (Suszkowski, 1978). The typical salinity of the Bay water is in the range of 10 to 20 parts per thousand (ppth), indicative of freshwater mixed with seawater (approximately 30 ppth).

Typical water level changes in the Bay are dominated by the astronomical tides, with wind effects providing an additional influence. Tides in the Newark Bay area are semidiurnal with a mean tide range of 5.1 ft and a spring tide range of 6.1 ft. The mean tide level is 2.5 ft above MLW, and mean lower low water (MLLW) is 0.2 ft below MLW (USACE, 1997a).

Tidal extremes or other extreme water level changes are caused by storms, either of tropical or extratropical origin. These storms generate wind and pressure changes that result in storm surge. Storm tides in the Newark Bay area can raise water levels to elevations of 5.9 ft above mean sea level for a two-year return period storm, to 8.7 ft above mean sea level for a 100-year return period storm (USACE, 1997a).

The longest fetch in the Bay coincides with its geographical orientation (i.e., southwest to northeast), and the largest waves approach from that direction. Potential wave heights can be over 6 ft for the most severe storms, but are typically less than 4 ft (USACE, 1997a). Wind-generated currents, although not a constant phenomenon, affect water mixing and sediment transport within Newark Bay (USACE, 1997a).

Tidal currents are the primary mechanism of water flow within Newark Bay, and are strongest (both ebb and flood) in the Arthur Kill and Kill van Kull. Peak tidal currents within the Bay vary according to reach. The maximum ebb tidal current velocity is 1.6 knots directed toward the southwest near Port Elizabeth, while the maximum flood tidal current velocity is 1.8 knots directed toward the northeast near the mouth of the Hackensack River. The weakest tidal currents are found below the South Elizabeth Channel (west side), and in the cove south of Droyers Point (east side) (USACE, 1997a).

The dominant freshwater contributions to Newark Bay come from the Passaic River and the Hackensack River at the north end of the Bay, and saltwater is delivered by tidal exchanges through Arthur Kill and Kill van Kull at the south end of the Bay. Due to the volume of freshwater flowing out of the Passaic River, density stratification in Newark Bay is greatest at the mouth of the Passaic River. Salinity is highest and stratification is weakest in the Kill van Kull due to high exchange with New York Harbor (Suszkowski, 1978). Annual flow computations by Blumberg et al. (1999) show approximately 60% of annual flows into Newark Bay come from the Kill van Kull, and 34% from the Hackensack and Passaic Rivers combined, while net discharge to Raritan Bay occurs through Arthur Kill.

Data presented by Hunter et al. (2002) show that non-tidal, density-driven circulation occurs in the system and is most pronounced in the Newark Bay Channels, weakest in the Kill van Kull, and variable in the Arthur Kill at Perth Amboy.

A water and sediment budget was developed for Newark Bay by Suszkowski (1978). A significant finding was that the Kill van Kull is the largest contributor of inorganic sediment to Newark Bay, as opposed to the Passaic

River, which is the major freshwater contributor. Suszkowski reported that 31% of incoming inorganic sediments are from the Passaic and Hackensack Rivers combined; 5% are from internal sources (e.g., wastewater discharges, and urban runoff); and the remaining 64% is from the seaward boundaries (Kill van Kull and Arthur Kill). The dominance of the sediment supply from the Kills has important implications for their potential contributions of sediment-bound chemicals. Recent transport data presented by academic researchers also indicate that Arthur Kill and Kill van Kull are sediment sources to Newark Bay (Styles et al., 2001; Haldeman et al., 2002; Hunter et al., 2002).

2.1.6 Climate

The information provided by USACE (1987) indicates that the climate for Newark Bay and surrounding areas is characteristic of the Middle Atlantic Seaboard, where marked changes in weather are frequent, particularly in the spring and fall. Winters are moderate, with snowfall averaging approximately 34 inches annually from October through mid-April. Winters are controlled by polar continental air masses that descend from Canada across the Great Lakes into the region. Summers are moderate with sporadic heat waves. Coastal areas are cooled by daytime winds off the Atlantic Ocean.

Rainfall is moderate and distributed fairly uniformly throughout the year, averaging approximately 47 inches annually with an average of 121 rainy days per year. The region may be influenced by seasonal tropical storms and hurricanes between June and November, which can bring the heaviest rainfalls (Carswell, 1976). Thunderstorm and tropical storm activity is most likely to occur in the summer, although some occur in the fall, and northeasters can occur from November to April.

The average annual temperature in Newark is 54 degrees Fahrenheit (°F); with extremes from -26 °F to +108 °F. Mean relative humidity varies from 67 to 73%.

Based on data from Newark Liberty International Airport, prevailing winds in the Newark area are from the southwest, with small seasonal variations in direction (www.wcc.nrcs.usda.gov/climate/windrose.html). By season, the mean wind direction for the winter months is west-northwest (35% of the time), while southwest winds predominate (32% of the time) during the summer. Mean wind speeds are generally highest during the winter and spring months (10 to 12 miles per hour), and lower (7 to 9 miles per hour) during the summer months, with an average annual velocity of approximately 10 miles per hour.

2.2 Historical and Current Usage

During the past two centuries, Newark Bay has been subject to multiple influences and changes due to variations in hydrological, topographical/bathymetric, climatological, and ecological conditions. However, of greater significance have been changes due to rapidly expanding urban and industrial development in the region. Environmental degradation of the Newark Bay area has resulted from many factors, including habitat destruction, wetlands drainage, land alteration, garbage and sewage disposal, and releases of hazardous substances into the environment (Iannuzzi et al., 2002).

The growing population of Newark during the first half of the twentieth century resulted in the generation of increasing volumes of human wastes (Suszkowski et al., 1990). Efforts to improve the water quality and to reduce the spread of disease in the Newark area led to the construction of a trunk sewer line system in 1924 (Brydon, 1974). Despite the development of sewage treatment plants, many industrial facilities located along the Passaic River were not connected to the Passaic Valley Sewerage Commissioners (PVSC) trunk line until the late 1950s (Brydon, 1974). The Joint Meeting of Essex and Union Sewerage Authority constructed a trunk sewer line in 1904 that conveyed waste from points west to the Arthur Kill. However, the City of Elizabeth continued to discharge raw sewage to the Arthur Kill until 1960. Other sewerage authorities developed along the Bay and its tributaries during the past century include Port Richmond (Staten Island, NY), Bayonne, Jersey City, and Kearny. Each of these sewerage systems evolved in response to the increasing volumes of domestic and industrial waste discharges. Typical to these systems was the utilization of CSOs to allow the overflow of waste directly to the Bay and its tributary waterways in times of peak flow and/or precipitation.

In addition to degraded sediment and water quality, the expansion of industry and population surrounding Newark Bay resulted in a severe loss of natural habitat for indigenous and migratory biota (Squires and Barclay, 1990; Crawford et al., 1994). For the past 150 years, development along Newark Bay has been spurred by extensive dredging, massive bridge construction, and heavy commercial shipping (Iannuzzi et al., 2002). Almost all of the wetlands adjoining Newark Bay have been eliminated. In total, more than 21,800 acres (88% of total) of wetlands have been eliminated from the area covering the lower Passaic and Hackensack Rivers, and Newark Bay watersheds (Iannuzzi et al., 2002).

The following sections present a discussion of the historical and current demography and land use, ecology, constituent sources, and dredging related to Newark Bay. Additional information is provided in RIWP Volume 1 (Tierra, 2004).

2.2.1 Historical and Current Demography and Land Use

Newark Bay has a long history of industrialization dating back more than two centuries (Meyers, 1945; Cunningham, 1954, 1966a and 1966b; Brydon, 1974). By 1850, Newark was home to several chemical companies producing a diverse range of chemical products and raw materials (Cunningham, 1954; Zdepski, 1992). By 1900, Newark was the largest industrial-based city in the U.S., with well-established industries such as petroleum refining, shipping, tanneries, creosote wood preservers, metal recyclers, and manufacturers of materials such as rubber, rope, textiles, paints and dyes, pharmaceuticals, raw chemicals, leather, and paper products (Meyers, 1945; Cunningham, 1954 and 1966a; Brydon, 1974; Halle, 1984; MacRae's, 1986; Galishoff, 1988). World Wars I and II promoted further urban and industrial growth in the region (Squires, 1981). Commercial use of local waterways also greatly expanded during the period between 1920 and 1950 (Squires, 1981).

Land use along the northern, western, and southern shoreline of Newark Bay is high-density commercial and industrial/commercial development. A highly developed network of highways, CSOs, SWOs, and POTWs also exist within the Bay (Mueller et al., 1982).

2.2.2 Historical and Current Ecology

The expansion of industry and population surrounding Newark Bay has resulted in a severe reduction in the availability of natural habitats for indigenous and migratory biota (Squires and Barclay, 1990). Much of the City of Newark occupies land once dominated by salt marshes associated with the Newark Bay system. The original salt marsh has been filled with more than 21 million tons of material, including industrial and municipal wastes, dredge materials, and railroad cinders (Zdepski, 1992). Early settlers graded hills and filled portions of the wetlands for cultivation (Urquhart, 1913). Drainage ditches and tidal exclusion dikes were built throughout the colonial period, and much of the marshland east of Newark was ditched by the late 1700s (Headlee, 1945). When industry expanded, ditching and diking accelerated. By the early 1900s, the majority of salt marshes were filled with solid wastes, and pesticide application was routine in an effort to eliminate mosquito breeding areas (Zdepski, 1992; Rod et al., 1989). With the industrial growth of the Newark Region beginning in the mid-19th century, came a series of added environmental impacts to the waterways and ecological resources of the area. Most notable of these incremental impacts are habitat loss, changes in ecological community structure and composition, and pollution.

Tidal creeks and marshes provide vital habitat for resident and migratory fish (Kneib, 1997), and it is likely that wetland and tributary losses contributed greatly to the severe declines and losses of fish in the latter half of the nineteenth century and the first half of the twentieth century (Iannuzzi et al., 2002). In the mid-1800s, Wheeler's, Maple Island, and Pierson's Creeks were cut off from Newark Bay by tide gates. This eliminated tidal flow and reduced energy flow to and from the marshes, lowered salinity, and kept estuarine fish out of the creeks (Talbot et al., 1986). Because some marsh-estuarine fish species, including mummichogs and other killifish, must utilize the marsh surface to obtain a portion of their energy requirement (Weisberg and Lotrich, 1982), excluding tidal flow (and thus energy flow) from the marshes dramatically reduced their populations.

Dredging has also played a significant role in aquatic habitat loss and altering the ecology of Newark Bay by physically damaging the bottom, mobilizing smothering sediments, remobilizing contaminants that had been buried in sediments, and increasing ammonia concentrations in water. Past, current, and future dredging activities are further discussed in Section 2.2.4.

Large-scale changes in aquatic community structure and composition have also taken place in Newark Bay. It has been estimated that about 200 species of edible fish and shellfish existed in the Newark Bay region prior to European settlement (McCormick and Quinn, 1975; Santoro et al., 1980; Quinn, 1998). Early residents of the area relied on fish and shellfish for food (Quinn, 1997). Anglers could catch a "basket-full" in one hour with a rod and line, and fish would come to the surface and feed when fishermen rinsed bait from their hands (Holmes, 1885 and 1890). Fishermen from around the region traveled to Newark Bay to enter fishing contests (Lee, 1902). In the early 1800s, Newark Bay was "oyster-rich" (Smith, 1887; McCay, 1998). Thousands of bushels of seed oysters were harvested from Newark Bay and planted elsewhere, including San Francisco Bay, Great South Bay, and New York Bay (Ingersoll, 1887). In 1882, over 175,000 bushels of oyster seed were harvested over a period of seven months (MacKenzie, 1992).

Populations of fish and shellfish within Newark Bay and surrounding areas have been substantially reduced by pollution, in addition to habitat loss and overfishing (Mytelka et al., 1981; Esser, 1982; Franz, 1982). As early as the Civil War, sales of oysters and shad were affected by reports that the organisms from Newark Bay were "tainted with coal oil and off flavors" (Earl, 1887; Squires, 1981). The Commission of Fisheries of New Jersey reported in 1885 that water-borne pollution was resulting in declining fish populations in the Passaic River (Esser, 1982). After 1900, conditions of the fisheries in Newark Bay deteriorated rapidly. In 1905, the Report of the Commissioner of the Fisheries no longer listed Newark Bay as a commercial fish source (Iannuzzi et al., 2002). A significant commercial fishery has not operated in Newark Bay since the early 1900s (McCormick and Quinn, 1975). In 1926, a survey conducted in the area by the U.S. War Department found fish populations "destroyed" (Hurley, 1992). Recent studies of the lower Passaic River report the presence of some fish and benthos known to be highly tolerant of reduced dissolved oxygen levels, implying the presence of a stressed aquatic system (Festa and Toth, 1976; Santoro et al., 1980; Princeton Aqua Science, 1982). Depressed levels of dissolved oxygen have been known to be a chronic problem in Newark Bay and its tributaries since the early 1900s (McCormick et al., 1983). Investigations conducted prior to 1940 by the Interstate Sanitation Commission indicated substantially decreased levels of dissolved oxygen throughout the region during the early part of the century (Interstate Sanitation Commission, 1939).

Based on the results of monitoring and research undertaken since the mid-1970s, the State of New Jersey has taken several steps via consumption advisories, closures, and bans on fish sales to limit the exposure of the fish-eating public to toxic chemicals in the Bay. The initial measures prohibited sales and advised against consuming several species of fish and eel based upon the presence of PCBs. The State of New Jersey began evaluating fish bioaccumulation of PCBs in state waters in 1975. The first report (New Jersey Department of Environmental Protection [NJDEP], 1982) resulting from this effort, with data gathered from 1975 to 1980, showed that 75% of finfish and 50% of shellfish had detectable levels of PCBs in their flesh (> 0.1 parts per million [ppm]). The heavily urbanized northeastern portion of the state had the most severe contamination.

A second report was released in 1983 (NJDEP, 1983) with data from sampling conducted in 1981 and 1982, which concentrated on the Hudson River-Newark Bay-Raritan complex and adjacent ocean waters. In addition to PCBs, limited sampling of bluefish for chlordane was conducted in those years. The PCB data from this report led to the establishment of consumption advisories and fishing bans in late 1982. The measures were adopted as an emergency rule late in 1982 and readopted as a permanent rule with minor changes early in 1983. The sale of striped bass and American eel from the Hudson River, upper New York Bay, Newark Bay, lower Passaic River, lower Hackensack River, Arthur Kill, and Kill van Kull was prohibited. In 1983, PCDD/PCDFs were identified in fish from the Passaic River and in 1984, the NJDEP issued additional consumption advisories (NJDEP, 1985a and b). A limited consumption advisory for the northeast region included the following species: striped bass, American eel, bluefish, white perch, and white catfish (New Jersey Department of Environmental Protection and Energy, 1993).

Three administrative orders established consumption advisories and fishing closures in Newark Bay. Administrative Order EO-40-1, dated June 2, 1983, advised against consuming fish or shellfish taken from Newark Bay, the lower Passaic River, the lower Hackensack River, the Arthur Kill, and the Kill van Kull. Administrative Order EO-40-17, dated October 19, 1983, superceded the previous order, and continued the advisory against consuming fish or shellfish taken from Newark Bay, the lower Passaic River, the lower Hackensack River, the Arthur Kill, and the Kill van Kull. Administrative Order EO-40-19, dated August 6, 1984, continued the prohibition against selling or consuming fish or shellfish taken from the lower Passaic River, but added a prohibition on the sale or consumption of striped bass and blue crabs taken from Newark Bay, the tidal Hackensack River, the Arthur Kill, and the Kill van Kull (New Jersey Department of Environmental Protection and Energy, 1993).

2.2.3 Historical and Current Constituent Sources

Dating back to post-Civil War times, a significant portion of the contamination of Newark Bay and its tributaries was due to industrial operations. There were a large number of mills and manufacturing plants that used the waterways and wetlands as a means for disposing of their waste materials. In addition to the direct discharge of process wastes to these waterways, many of these industries also landfilled wastes at sites located within the drainage basin of Newark Bay. These industries included metals refining, dye manufacturing, tanning, soap and candle making, lumber processing, hat manufacturing, carriage building, shoe making, petroleum processing, chemical manufacturing, paper and textile manufacturing, copper rolling, wire manufacturing, silver manufacturing, and platinum refining (Iannuzzi et al., 2002). Also, ship building, coke making, decommissioning, manufactured gas plants, and other heavy manufacturing companies utilized the waterways.

In addition to manufacturing wastes, contamination of the waterways and surrounding areas of the Bay have been linked to a number of specific occurrences and non-point sources such as those presented below (Iannuzzi et al., 2002):

- oil pipeline crossing Saddle River burst in the late 1800s, covering miles of the river from shore to shore with oil;
- tanker spill of carbolic acid in the spring of 1880;
- electronics manufacturing in the early 1900s;
- spreading of lightweight fuel oils on mosquito-infested wetlands and marshes in the early 1900s;

- production of anti-fouling marine paints containing mercury;
- copper fungicide application used on farmlands and watersheds to address mosquito infestation in the 1940s; and
- DDT application on mosquito-infested wetlands, marshes and stormwater system infrastructure in the 1950s and 1960s.

Examples of recent non-point sources include the following spills:

- spill of sodium phosphate to the Arthur Kill in August 1987 (Gunster et al., 1993a,b);
- oil pipeline crossing the Arthur Kill ruptured in January 1990 releasing thousands of gallons of No. 2 fuel oil (NJDEP, 1991); and
- spill of fuel oil to Newark Bay in October 1991 (Gunster et al., 1993a,b).

RIWP Volume 1 (Tierra, 2004) contains a discussion of pollutant and contaminant sources to Newark Bay including accidental spills and point sources.

A significant source of contamination was the direct input of raw sewage into Newark Bay and its tributaries from surrounding communities. On the Passaic River, a trunk sewerline was installed in 1924 in an attempt to combat the immense amount of untreated sewage and industrial waste that was pouring into the river. This trunk sewerline installation was driven by the desire to upgrade the water quality and to revive recreation activities along the river. However, the new system was a combined sanitary and stormwater conveyance system which was designed to overflow to the adjacent waterway via combined sewer outfalls when capacity is exceeded during precipitation events. Therefore, while the trunk sewerlines helped to improve the water quality of the area, they did not eliminate the discharge of untreated domestic and industrial waste, including numerous chemical contaminants and pathogens.

Newark Bay and its other tributaries have a similar history with the direct input of raw sewage. The City of Elizabeth discharged raw sewage into the Arthur Kill prior to finally connecting all of the City into the Joint Meeting of Essex and Union POTW in 1960. CSOs from sewerage districts in Elizabeth and Newark overflow into the Peripheral Ditch, a direct tributary to Newark Bay's Elizabeth Channel. These Newark CSOs have a significant history of dry-weather overflows which necessitated the construction of an interceptor sewer and pumping station to the PVSC POTW in 1965. Jersey City, Kearny, and Port Richmond on Staten Island constructed POTWs to serve their local needs in the 1950s and 1960s. The Port Richmond plant upgraded from primary to secondary treatment in 1979; Jersey City and Kearny discharged primary treated waste to the Bay until 1989/1990, when they began diverting all flow to the PVSC POTW. The City of Bayonne POTW, with 16 CSOs that discharge to the Bay and Kill van Kull, also began diverting flow to PVSC in 1990 rather than upgrade to secondary treatment.

Historically, there have been water quality problems in the Bay, specifically low dissolved oxygen and high biochemical oxygen demand, nutrient levels, ammonia concentrations, and fecal coliform levels. A number of chemicals including metals, PAHs, pesticides, PCBs, PCDDs, PCDFs, volatile compounds, and semi-volatile compounds are present in the sediments and aquatic organisms within the Bay's waterways. Key sources continuing to plague the Bay today include POTWs, CSOs, NPDES-permitted discharges, SWOs, and stormwater runoff.

To date, several CSOs, SWOs, and POTWs have been identified as potential past and current sources to Newark Bay (Section 2.2.2.6 and Figures 3-21 and 3-22 of RIWP Volume 1 [Tierra, 2004]). A characterization of specific sources will be performed pursuant to Paragraph 44 of the AOC, and Section B.3.b.iii.(2) of the SOW.

2.2.4 Overview of Dredging Activities in Newark Bay

2.2.4.1 Historical Dredging and Filling Operations

Dredging was first initiated in the Newark Bay area in 1860 to accommodate deep-draft vessels. Between 1891 and 1934, substantial development by the federal government led to the construction of a series of federal navigation channels and a large marine terminal at Port Newark. The large quantities of dredged material removed during bay development activities were used as fill at Port Newark, or as fill in large stretches of Newark Bay's eastern shoreline to facilitate industrial, residential, and recreational development. Since 1934, maintenance dredging activities have taken place periodically within Newark Bay and its tributaries. Table 2-2 lists the known dredging activities in the Bay from 1940 to the present.

As indicated, Newark Bay has been subject to extensive filling through the disposal of dredged material. Suszkowksi (1978) reports that until about 1969, over 75% of dredged material were deposited in adjacent upland disposal sites, generally as fill material for use in development. Suszkowski (1978) combined information on federal and private dredging projects from 1944 to 1976, and determined that 61% of the material dredged during this period was deposited in upland areas. Between 1855 and 1976, Suszkowski (1978) estimated that filling had reduced the area of Newark Bay by about 20%, as shown in the following table:

Newark Bay Area Reduction

Year	Newark Bay Area (ft^2)	% Reduction from 1855 Area
1855	6.43×10^7	-
1886	6.40×10^7	0.5%
1934	5.35×10^7	16.5%
1976	4.27×10^7	20.1%

ft^2 = square feet

Figures 2-3 and 2-4 illustrate the changes in the western shoreline from 1936 to 1986.

Filling may have resulted in the relocation of historical contaminated sediments to the shoreline, or other areas outside the navigation channel. Dredging and filling activities may also have resulted in the transfer of these materials to depths greater than that associated with “natural” deposition.

2.2.4.2 Current Dredging Practices and Conditions

Maintenance dredging and deepening of the navigation channels within Newark Bay are primarily the responsibility of the USACE. In order to maintain a safe navigable depth, the USACE monitors the depths of the harbor channels on a rotating six-month schedule, and if necessary, coordinates maintenance dredging activities. Figure 2-1 shows the current depth of the Bay’s navigation channel, and the year in which dredging last occurred, based on existing information.

The PA NY/NJ also helps to maintain navigable depths in channels and berths, specifically Port Newark Channel, Port Newark Pierhead Channel, Elizabeth Channel, and South Elizabeth Channel. The PA NY/NJ and the USACE often work in conjunction to better service the navigational needs of the area.

In addition to monitoring the depth of the federal navigation channels, the USACE is also responsible for issuing permits to private organizations for the purpose of dredging private waterfront property outside of the navigation channel. Table 2-3 lists permitted dredging activities in the Bay from 1940 to the present, based on existing information.

There are currently two known federal dredging projects being conducted in the Bay: the Arthur Kill Channel and Howland Hook Marine Terminal Deepening Project, and the New York/New Jersey Harbor Deepening Project. As part of the first project, dredging (to 41 ft) is currently ongoing in the 2.7 miles north of the Goethals Bridge (USACE, 2004a). The details of the New York/New Jersey Harbor Deepening Project are discussed below in Section 2.2.4.3.

For purposes of safely and effectively implementing this Phase I SI Program, Tierra will meet with USEPA and USACE prior to mobilization. One of the specific purposes of this meeting will be to determine whether on-going (or future) dredging activities might affect Tierra's ability to collect the samples proposed in this IWP.

2.2.4.3 Future Dredging in the Bay

As part of the New York/New Jersey Harbor Deepening Project, the USACE and PA NY/NJ are currently working together to deepen the South Channel, portions of the Middle Channel, the Arthur Kill north of the Goethals Bridge, and the Kill van Kull to a depth of 50 ft (53.5 ft in rock). This work was authorized through the Water Resources Development Act of 2002, and includes the following contract areas within the Newark Bay Area (Figure 2-2) (USACE, 2004a):

- Arthur Kill, north of the Goethals Bridge – will be dredged to 50 ft as part of contract areas S-AK-1, S-AK-2, and S-AK-3, with anticipated construction start dates of September 2006, January 2008, and January 2009, respectively.
- Kill van Kull – dredging began in April 2005 and is currently ongoing to 50 ft as part of contract area S-KVK-2.
- Middle Channel/South Channel/South Elizabeth Channel/Elizabeth Port Authority Marine Terminal – will be dredged to 50 ft as part of contract areas S-NB-1 and S-NB-2, with anticipated construction start dates of October 2005 and June 2009, respectively. In addition, the South Elizabeth Channel will be widened to 500 ft, and the berthing areas along the Elizabeth Port Authority Marine Terminal will be widened to 150 ft.
- Elizabeth Channel – will be dredged to 50 ft as part of contract area S-E-1 with an anticipated construction start date of April 2011.

As part of this Contract, the estimated total volume of dredged material to be removed is 42,500,000 cubic yards (cy), with 31,288,000 cy to be placed at the Historic Area Remediation Site and the remaining volume to be placed at upland locations, including but not limited to, the Pennsylvania Mines and New York and New Jersey Quarries. The estimated completion date of the Harbor Deepening Project is fall 2011 (USACE, 2004a).

In addition to the Harbor Deepening Project, navigation channels are also subject to periodic maintenance dredging, depending upon the rate of sediment accumulation in a given area.

3. Preliminary Conceptual Site Model

This section presents a preliminary conceptual site model (CSM) for Newark Bay that was used to develop the Sediment Sampling Program presented in Sections 4 and 6 of this IWP. USEPA guidance – *Data Quality Objectives Process for Hazardous Waste Site Investigations* (USEPA, 2000a) – identifies CSM development as one of the first and most important activities in sampling plan design, advocating that a CSM should be initiated at the start of a project and carefully maintained and updated throughout the life of the site activities. USEPA's *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (USEPA, 2002a) specifically calls for the use of a CSM in the decision-making process for sediment sites.

Typically, CSM development is conducted by compiling available historical data to provide a description of the site (USEPA, 2000). For sediment sites, USEPA indicates that a CSM should identify known and suspected sources of contamination, the types of contaminants and affected media, existing and potential exposure pathways, and the known or potential human and ecological receptors that may be threatened (USEPA, 2002a). The CSM should also consider the implications of sediment stability on current and future availability of contaminants (USEPA, 2002a).

The preliminary CSM developed herein primarily relies on RIWP Volume 1 (Tierra, 2004). A preliminary CSM diagram is presented in Figure 3-1. The diagram illustrates the likely sources and sinks of contaminants in Newark Bay, as well as the fate and transport processes that control the movement of contaminants within and out of the system, including (but not limited to) exchanges with the primary tributaries of Newark Bay—the Passaic and Hackensack Rivers to the north, and the Arthur Kill and Kill van Kull to the south.

The following sections provide additional details regarding the primary components of the preliminary CSM, including the geomorphology, hydrodynamics, and ecology of Newark Bay, the fate and transport processes for sediments and contaminants in the Bay, and potential pathways for wildlife and human exposures to contaminants. This CSM will be developed further as additional information is acquired through the RI process.

3.1 Newark Bay Physical Characterization

This section summarizes the geomorphology, hydrodynamics and sediment transport processes, and ecology of Newark Bay. It is these characteristics of the Bay that determine the fate and transport of contaminants that enter the system.

3.1.1 Geomorphology

The regional geomorphology of Newark Bay is summarized by NOAA (1984), and a more detailed description is provided by Suszkowski (1978). During the Pleistocene period of glaciations the ancestral channels of the Hudson, Raritan, Hackensack, and Passaic Rivers were established in the glacial outwash plain along the Atlantic coast, and became submerged as the sea level rose and the land surface rebounded. The rise in sea level reduced flow velocities and created long-term permanent depositional environments in the coastal plain estuaries (Roman et al., 2000). Deposition of riverine sediments contributes substantially to estuarine infilling; however, tidal processes (Postma, 1967) and estuarine circulation (Meade, 1969) also deliver significant marine sources of sediment to these estuaries, and also transport river-derived sediments back up-estuary, contributing to infilling over decadal time scales.

Reported findings of a geochemical assessment of sedimentation in the Hudson-Raritan estuary indicate that the sediments in wide, shallow sub-tidal flats of the system are in a state of dynamic equilibrium with the current, wave, and flow regimes (NOAA, 1984). Suszkowski (1978) evaluated resuspension by wind-waves at two locations in the sub-tidal flats and concluded that erosion by wind-waves can be considered significant at high wind speeds, but that erosion-causing winds occur less than 3% of the year. The NOAA (1984) study reported net sedimentation rates in these shallow areas of the Hudson-Raritan estuary based on radiochemistry profiles in sediment cores (including two cores from Newark Bay) to be 1 to 3 millimeters per year (mm/yr) (0.04 to 0.12 inches per year [in/yr]), consistent with findings by Suszkowski (1978), who used comparisons of historical bathymetric maps in Newark Bay. Assuming that the sediment surface is in dynamic equilibrium with wave and current conditions, these rates apparently reflect the rate of sea level rise or land subsidence (NOAA, 1984). Contrary to Suszkowski's work, recent field measurements presented by Burke et al. (2002) show that wind waves are frequently large enough to remobilize surficial sediments on the sub-tidal flats, which would be expected to occur in a condition of dynamic equilibrium with wave conditions.

Due to the intensive dredging history of Newark Bay (Section 2.2.4), the effects of such activities have had a major influence on the geomorphology of the Bay over the past 100 years. The infilling of Newark Bay by natural sedimentation processes since the end of the glaciation period has been offset by over 120 years of dredging, although dredging was accompanied by shoreline filling which reduced the overall area of the Bay. Suszkowski (1978) estimated that since 1855, dredging has increased the average depth of Newark Bay from 2 meters (m) to 3.1 m (6.6 ft to 10.2 ft) below MLW, and removed sediment from Newark Bay at a rate 280% greater than natural sedimentation since 1944. Through a detailed analysis of historical bathymetric data, Goldsmith et al. (1993) showed that between 1845 and 1989 the volume of water within Newark Bay increased by 33 million cy (99%), the maximum depth increased from 21 ft to 45 ft (114%) (note that no datum is provided by the author), and the area of Newark Bay decreased 4 million square yards (21%). These authors (Goldsmith et al., 1993) conclude that most of this activity occurred after 1948.

Federal navigation channels, including the Port Newark and Elizabeth Channels, cover approximately 30% of the current surface area of the Phase I SI Study Area, and are zones of preferential deposition, or areas where sediment focusing can occur. NOAA (1984) estimated that 90% of annual sediment deposition in Newark Bay occurs in the navigation channels, and the associated shoaling rates (i.e., deposition rates) are reported to be one to two orders of magnitude greater than in the sub-tidal flats (Suszkowski, 1978; NOAA, 1984; USACE, 1986).

Dredging may also play a role in redistributing historical sediments within Newark Bay. Suszkowski (1978) observed dredge plumes visible in 1972 aerial photographs from multiple active dredging and filling operations. Suszkowski also reports that some dredged material was deposited within the open waters of Newark Bay during the period 1944 to 1976, and that approximately 61% (or 19.4×10^6 cubic meters [m^3] [6.85×10^8 cubic feet [ft^3]]) of dredged material produced during this period was deposited on upland areas adjacent to the Bay. Since 1976, the large majority of the material dredged from the Bay has been disposed in the open ocean; however, in recent years alternative disposal options (i.e., upland disposal, beneficial reuse, abandoned coal mines, etc,) have been developed.

Extensive shoreline filling also has had a large impact on sedimentation and circulation patterns in Newark Bay. Section 3.3.1.5 of the RIWP Volume 1 (Tierra, 2004) provides historical maps of wetlands that illustrate the shoreline filling. Additionally, based on a comparison of NOAA bathymetric charts, Suszkowski (1978) reported that between 1855 and 1976 the area of Newark Bay was reduced by approximately 20%. The greatest filling occurred prior to 1934; however, a substantial portion of Newark Bay was also filled between 1934 and 1976. Figures 2-3 and 2-4 illustrate the shoreline changes from 1936 to 1986. Shoreline filling with dredged material may have resulted in the relocation of historical contaminated sediments to fringe areas of Newark Bay. The most extensive filling occurred along the western shoreline in the Port Newark area and northward (USACE, 2005b), and in a number of locations along the eastern shoreline (Suszkowski, 1978). As a result, existing near-shore sediments in these areas may be comprised of historical dredged materials. Groundwater discharge through these dredged materials may be a pathway for re-mobilization of contaminants into Newark Bay.

Dredging and filling may have altered circulation and sedimentation patterns from those that existed in previous decades. Suszkowski (1978) concluded that the most important change is the transition of the southwestern portion of the Bay from an erosional or scouring area to a depositional area.

3.1.2 Geomorphic Features

There are a number of distinct geomorphic features of Newark Bay that can be distinguished based on water depth, shoreline modifications, and areas affected by dredging and filling. This preliminary CSM describes the main geomorphic features of Newark Bay and their general sedimentary characteristics. The sampling program presented in Section 6 of this IWP considers select geomorphic features as sampling areas, and proposes collection of sediment cores within each selected area.

The dominant geomorphic features of the Bay are the federal navigation channels and the broad sub-tidal flats between these areas and the Bay shoreline. The navigation channels (in combination with the port channels) and sub-tidal flats occupy approximately 30% and 52% of the total surface area of the Phase I SI Study Area, respectively. Transitional slopes occur along the dredged channels, between the dredged channels and the sub-tidal flats. Inter-tidal areas (frequently exposed during low tide) occur in relatively small localized areas around Newark Bay. Other important features of Newark Bay include the highly-developed waterfronts with piers and shipping facilities, and the CDF established by the USACE (1997a) near Port Newark. The approximate percent of the total area within the Phase I SI boundary covered by each of these areas is summarized in the table below. Figure 3-2 shows a delineation of these areas, and the remainder of this section provides a description of each area germane to the design of the Phase I SI Program. [Note – these areas will now be capitalized given their specific relevance to the IWP.]

Geomorphic Area Breakdown

Area	Percent of the Phase I SI Study Area
Navigation Channels	25%
Port Channels	5%
Transitional Slopes	8%
Sub-tidal Flats	52%
Inter-tidal Areas	2%
CDF	<1%
Industrial Waterfront Areas	8%

3.1.2.1 Navigation Channels/Port Channels

The Navigation Channels include the main federal channels along with the Elizabeth, Port Newark, and South Elizabeth Channels. Together, these features cover 30% of the Phase I SI Study Area. Other private dredged channels lead from the Navigation Channels to various waterfront facilities, particularly along the industrial waterfront on Staten Island, and along Bergen Point on the southeast side of the Bay. The Navigation Channels in Newark Bay from Port Newark southward have been dredged within the last three years (since 2001), and have been maintained at depths of 35 to 50 ft below MLW. North of Port Newark to the mouths of the Passaic and Hackensack Rivers, the channel was last dredged in 1989, at which time the project depth was 35 ft below MLW. Multiple dredging actions have occurred in the Navigation Channels since the 1940s, and have tended to deepen and widen the channel, modifying or eliminating the 1940 depositional horizon in these areas (USACE, 1997a). Section 2.2.4 presents an overview history of dredging operations in Newark Bay.

The Navigation Channels are unique from the rest of Newark Bay. Because of the deeper depths, the channels are not subject to wind-wave resuspension, and accumulate sediments resuspended from the Sub-tidal Flats. Preferential deposition areas in the channels may be along the sides of the channel where sediments would be least subject to potential navigation-induced resuspension.

USACE (2004a) characterizes the Newark Bay reaches as consisting of fine silts and clays, indicative of relatively low-energy velocities and high deposition rates, with the notable exception of the South Reach (Figure 1-2). In the South Reach area, tidal currents are not conducive to deposition, and the bottom, therefore, is mostly sand and gravels (USACE, 2004a). In most areas, the channels experience much higher deposition rates than other areas of the Bay. The USACE reports deposition rates of 2 to 10 in/yr in the channels (USACE, 1986), whereas deposition rates of 1 to 3 mm/yr (0.04 to 0.12 in/yr) are reported for the Sub-tidal Flats (NOAA, 1984; Suszkowski, 1978). Deposition rates in Newark Bay reported by the USACE (1986) are summarized in the table below.

Reported Deposition Rates in Newark Bay Channels

Channel	Area	Deposition Rate (in/yr)
Navigation Channels	North	7
	Middle	5
	South	2
Port Channels	Elizabeth	4
	Port Newark	10
Arthur Kill	North of Shooter Island	11
	South of Shooter Island	5
Kill van Kull	--	Sporadic deposition pattern

The depositional process illustrated above can create the need for periodic maintenance dredging activities.

The channel sediments are potentially subject to resuspension and reworking by propeller scour from deep-draft, ocean-going ships calling on the port facilities. Mixing due to propeller-induced resuspension can modify or eliminate depositional profiles of radionuclides and chemicals. Suszkowski (1978) evaluated resuspension by deep-draft vessels and reported that vessel movements in at least half of the channel areas of Newark Bay produce significant amounts of resuspension.

3.1.2.2 Transitional Slopes

Transitional Slopes occur between the deeper dredged channels and the Sub-tidal Flats. This geomorphic feature covers approximately 8% of the Bay. The slopes are generally 3 to 1 based on observations from available NOAA bathymetric charts (Figure 3-3). The Transitional Slopes may have been created by cutbacks during dredging, slumping of Sub-tidal Flats into dredged areas, erosion, or some combination of these processes. To the extent that these areas were cut back during dredging, or dredging created unstable transitional slopes, re-exposure of historical buried sediments and/or reburial of dredging-exposed historical sediments may occur in these areas. Burke et al. (2002) hypothesized that the Transitional Slopes act principally as storage areas for sediment, and present field data suggest that periodic resuspension of transitional slope sediments occurs in response to wind, waves, and tidal currents. Waves and currents generated by passing vessels may also play a role in redistributing sediments on the Transitional Slopes. These processes could potentially promote the focusing of sediments within the Navigation Channels.

3.1.2.3 Sub-tidal Flats

The broad, shallow Sub-tidal Flats located outside of the Navigation Channels cover approximately 52% of the Phase I SI Study Area, based on the delineations shown in Figure 3-2. Water depths in the Sub-tidal Flats are generally between 1 and 20 ft below MLLW (NOAA, 1997; NOAA, 2002). As discussed previously, sedimentation rates in the Sub-tidal Flats are very low, on the order of 1 to 3 mm/year (0.04 to 0.12 in/yr), apparently reflecting a state of dynamic equilibrium with wave energy where sedimentation rates reflect sea level rise or land subsidence (NOAA, 1984). Recent data presented by researchers at Stevens Institute of Technology suggest that moderate wave and current conditions may remobilize surface sediments on the Sub-tidal Flats (Burke et al., 2002). Sediment cores collected in Newark Bay, the Arthur Kill, and Raritan Bay from "muddy" sediment areas not affected by dredging show that Cesium-137 (^{137}Cs) is confined to the top few centimeters (cm) (approximately 10 to 20 cm [3.9 to 7.9 inches] in the two Newark Bay cores representing three decades). This pattern indicates low net deposition rates in the Sub-tidal Flats (NOAA, 1984). The presence of a defined ^{137}Cs peak in this depth interval also suggests relatively high bed stability and limited mixing of buried sediments by resuspension.

3.1.2.4 Inter-tidal Areas

Many of the wetlands historically present around the fringes of Newark Bay have been filled, yet small Inter-tidal Areas remain and represent approximately 2% of the Phase I SI Study Area. These areas are normally exposed during low tide and inundated at high tide. This process may influence the depositional and erosional patterns.

3.1.2.5 CDF

As discussed in Section 2, a CDF (Cell 1S) was constructed within Newark Bay in 1997, and is currently in operation. In 2001, dredge materials from lower Manhattan (dredged to accommodate barges for removal of debris resulting from the September 11, 2001 terrorist attacks) were placed in the Newark Bay CDF (USACE, 2001). More recently, dredge materials from the Arthur Kill 41/40 project that were found unacceptable for beneficial reuse as structural fill material at upland sites were also placed in the CDF (USACE, 2005a). The actual Newark Bay CDF footprint comprises less than 1% of the Phase I SI Study Area.

3.1.2.6 Industrial Waterfront Areas

The Newark Bay shoreline (including the significant feeder tributaries) has been subjected to human modification over time, represented by a concentration of marine facilities, private dredged channels, POTWs, CSOs, NPDES-permitted discharges, SWOs, and other facilities. The large number of constructed pier and shipping facilities along the waterfront evidences extensive historical removal, reworking, and disturbance of sediments. These facilities also present numerous physical obstructions to water currents and may cause highly localized variation in sedimentation patterns. The apparent large number of discharge points provides a high potential for localized influence of diffuse urban sources of pollutants and chemicals, potentially masking the signature of sediments possibly derived from elsewhere in the Bay. Figure 3-21 of RIWP Volume 1 (Tierra, 2004) shows the locations of known CSOs around Newark Bay, while Figure 3-22 depicts the SWOs within the Lower Passaic River.

Example Industrial Waterfront Areas include, but are not limited to:

- Staten Island along the south side of the Bay;
- Ports of Elizabeth and Newark along the west side of the Bay;
- West side (Elizabeth) of North of Shooters Reach;
- East side (Bayonne) of South Reach;
- West side (Newark) of North Reach and Kearny Point Reach; and
- North end (east and west side) of Kearny Point/Droyers Point Reach.

For purposes of this IWP, areas within 100 ft of the entire shoreline within Newark Bay will be considered part of the Industrial Waterfront Area. The Industrial Waterfront Area covers approximately 8% of the Phase I SI Study Area.

3.1.3 Hydrodynamics and Sediment Transport

Newark Bay, which is part of the larger Hudson-Raritan estuary, is a density-stratified estuary with dominant freshwater contributions from the Passaic River and the Hackensack River at the north end of the Bay, and saltwater contributions from tidal exchanges through Arthur Kill and Kill van Kull at the south end of the Bay. Figure 3-1 conceptually depicts these inputs. As discussed in Section 2.1.5 of this IWP, the majority of the flow enters Newark Bay from the Kill van Kull (approximately 60%), with the remaining flow entering from the Hackensack and Passaic Rivers (approximately 34%) (Blumberg et al., 1999).

Pence (2004) recently studied and described the flow and circulation patterns in the Bay. Newark Bay is a complex estuary dominated by astronomical tides that are modified by the effects of freshwater inflow and meteorological events. The more saline waters (from the ocean) enter Newark Bay through Kill van Kull and Arthur Kill, while the dominant freshwater contributions to Newark Bay come from the Passaic River and the Hackensack River. Pence (2004) found that in the Newark Bay shipping channel, there is classical estuarine two-layer circulation with a seaward surface flow and a landward bottom flow. Over the side banks, there is a persistent flow downstream. However, strong wind events were shown to create large episodic flushing. Pence (2004) found that a west wind forces water out of Newark Bay through Kill van Kull and, conversely, an east wind forces water into Newark Bay through Kill van Kull. During these events, there is a smaller amount of flow through Arthur Kill as compared with Kill van Kull. On rare occasions when there are sustained extreme winds from the west, Arthur Kill can be the filling or emptying conduit of Newark Bay instead of Kill van Kull. Winds from the north and south (which are not as prevalent as the west and east winds) affect Arthur Kill locally. Overall, Pence (2004) showed that these episodic wind events disrupt the expected normal tidal patterns.

While sediment and contaminant patterns are not well-understood within the Bay, the tidal circulation patterns and influence of the wind-driven episodic events will play a role in the transport of sediments and contaminants. The processes influenced by the flow and circulation patterns include the transport of suspended sediments, sediment deposition, and erosion within the Bay (see Figure 3-1). Additionally, both past and recent transport data indicate that Arthur Kill and Kill van Kull are sediment sources to Newark Bay (Suszkowski, 1978; Styles et al., 2001; Haldeman et al., 2002; Hunter et al., 2002). Pence (2004) suggested that the Hackensack River is a sink for sediment suspended in the Passaic River and Newark Bay due to estuarine circulation.

3.1.4 Ecology

Newark Bay is a clear example of an urbanized ecosystem. The habitats that exist within and adjacent to the Bay, and in the proximal portions of its tributaries, are remnants of the original Bay ecosystem that contained a substantial area/diversity of wetland and aquatic habitats (Iannuzzi et al., 2002; Crawford et al., 1994). The original habitats have been substantially reduced through urbanization and industrialization during the conversion of Newark Bay to one of the world's largest commercial ports. Since the mid-19th century, more than 88% of the wetlands in the Newark Bay environs have been eliminated (Iannuzzi et al., 2002). The few wetlands that remain are relatively small and discontiguous.

The key habitats that remain in the Bay at present are the Sub-tidal Flats, and the Inter-tidal Areas—particularly the larger marsh/mudflat systems that are located at the north end of the Bay at Kearny Point, and at the southern end of the Bay adjacent to Staten Island. These habitats continue to provide forage areas, and possibly nursery areas for a variety of fish and invertebrates, and foraging areas for birds and other wildlife. The Sub-tidal Flats also likely provide forage habitat for a variety of aquatic organisms. Benthic habitats in Newark Bay tend to be dominated by silty-clay substrates and degraded by contaminants (USEPA, 1998; NOAA, 2000). As such, the infaunal communities are relatively impacted in terms of species diversity and abundance (NOAA, 1995; Cristini, 1991; Cerrato, 1986). In June and October 1995, NOAA (2000) assessed the benthic habitats and distribution in Newark Bay using sediment profile imagery (SPI) and benthic grab samples. They reported redox potential depths of less than 1 cm to greater than 3 cm. From the SPI, infaunal polychaetes were the primary benthic organisms observed, and no live shell beds were present (NOAA, 2000).

Despite the impacts of urbanization/industrialization, the existing data (as presented in Volume I of the RIWP) indicate that Newark Bay supports a variety of vegetation, and fish and wildlife species (USACE, 1999; U.S. Fish and Wildlife Service, 1997; NOAA, 1994). The predominant categories of organisms that have been reported are included as a conceptual food web in Figure 3-1. These include plankton/algae, aquatic and wetland plants, infaunal (benthic) invertebrates, bivalves (i.e., clams), crustaceans (i.e., shrimp and crabs), several trophic levels and types of fish, and a variety of birds. Additional types of wildlife that may utilize Newark Bay or the surrounding areas include amphibians, reptiles, and mammals.

3.2 Distribution of Contaminants in Newark Bay

As depicted in Figure 3-1, the distribution of contaminants within Newark Bay likely results from a variety of fate and transport processes. This section of the CSM describes the sources and sinks for contaminants in the Bay, as well as the extent of contamination and the potential human and ecological exposures to this contamination.

3.2.1 Contaminant Sources and Sinks

There are a variety of sources of contaminants to Newark Bay, and sinks for these chemicals within the Bay, as depicted in Figure 3-1. These are briefly discussed in this section and will be evaluated as appropriate during the RI/FS process for the Bay.

The most notable sources of contaminants to Newark Bay are direct industrial and/or municipal discharges, spills associated with shipping, non-point sources (e.g., overland flow), and the direct and indirect tributaries, creeks, and drainage areas to the Bay. Wastewater treatment plants and CSOs/storm sewers are key sources of a variety of contaminants that originate from municipal and industrial sources. In addition, throughout its history as a large commercial port, Newark Bay has experienced extensive shipping traffic and, consequently, a number of oil and contaminant spills (Gunster et al., 1993a,b).

Groundwater may also be a source of contamination to the Bay, associated not only with upland contamination impacting groundwater, but also in connection with shoreline areas that have been created through deposition of dredged or other fill material (much of it being dredged materials from Newark Bay), although relatively little is known in this regard.

Atmospheric deposition may also contribute contaminants to Newark Bay. The two primary mechanisms in which loadings of contaminants from the atmosphere could occur are precipitation (i.e., rainfall) and dry deposition. Dry deposition occurs when particulates with contaminants are transported and settle in the water column. Precipitation (rainfall or snowfall) can also convey particle-bound contaminants directly to the water column.

Totten et al. (2004) used measured fluxes of the sum of all PCB congeners (ΣPCB) at Sandy Hook, New Jersey and Jersey City, New Jersey to represent the flux into the Hudson River Estuary. Atmospheric deposition was estimated at approximately 10 kilograms per year of ΣPCBs into the Hudson River Estuary (assuming the plume of atmospheric contamination extends throughout Raritan Bay and the New York Harbor) (Totten et al., 2004). However, PCB congeners had different depositional/transportation trends. Overall, the author of the study concluded that atmospheric deposition of PCBs to the Hudson River Estuary is small.

Conversely, contaminants (i.e., mostly volatile organic compounds [VOCs] and semi-volatile organic compounds [SVOCs]) can be released from the water column to the atmosphere through volatilization. This is dependent on the volatilization rate of the specific compounds. It is not likely that this pathway represents a substantial loss mechanism for most of the organic and inorganic contaminants of primary concern in Newark Bay.

Within Newark Bay, the sediments act as a sink and means for transport throughout the Bay for a variety of contaminants. The processes that control the movement and deposition of sediments in the Bay were discussed in Section 3.1, including the fact that a large portion of the Bay is depositional in nature. From the sediments, contaminants may be re-mobilized through bioturbation within the biologically active zone (BAZ), sediment-pore water exchange, groundwater-pore water exchange, and sediment erosion and scour. Although bioturbation is a possible transport mechanism, results reported by Suszkowski (1978) indicate the benthic biomass found in Newark Bay was small, suggesting that the bioturbation process would minimally alter the rate of deposition or resuspension. This would indicate that bioturbation alone may not be a primary transport means for contaminants; however, when included with other processes occurring in the benthos of the system, the potential transport as a result of this process must be considered. The characteristics of various contaminants may also change once they are bound to sediments and deposited or buried in the Bay. Mechanisms include (but are not limited to) binding of metals and/or organic compounds into complexes that are less soluble or bioavailable, transformation of contaminants into other chemicals, and destruction/degradation. A brief description of the physicochemical properties of the primary contaminant classes found in Newark Bay sediments is provided in Section 3.2.2. It is these properties that primarily determine contaminant fate in sediments, including partitioning (i.e., sediments/pore water, sediments/surface water, pore water/surface water), and bioaccumulation potential and bioavailability.

Organisms that reside in the sediments, or forage at the sediment water interface, may be exposed to contaminants and be affected through direct toxicity, or bioaccumulate a variety of contaminants in their tissues. These organisms may then pass these contaminants to predators through food web interactions (i.e., bioaccumulation, biomagnification). While many species of fish and wildlife likely reside in Newark Bay, a substantial number are also migratory. As such, a number of organisms may export contaminants from the system during emigration. Conversely, migratory organisms may also bring contaminants into the system (from other waterways/exposures)—although this is not likely a substantial source of contaminants to or from the Bay.

3.2.2 Extent of Contamination

Very few studies have examined surface water contaminants in Newark Bay. In fact, most data collected to date focus on contaminant distributions in sediments. Available historical information on contaminants in Newark Bay sediment provides an indication of the horizontal distribution of metals and a few organic chemicals. Information on vertical distribution is more limited.

The available historical sediment data collected in Newark Bay since 1990 are presented in the RIWP Volume 1 (Tierra, 2004). Earlier datasets include those reported by Bopp and Simpson (1991) (which includes an attached copy of the published manuscript Bopp et al. [1991] that deals with a subset of the data that were collected), NOAA (1984), Meyerson et al. (1981), and Suszkowski (1978). These earlier datasets are important sources of historical data and information that can be used to help develop historical contaminant conditions for fate and transport modeling. However, when compared to the volume and types of Bay-area data obtained subsequently, they are not particularly useful for characterizing current conditions in Newark Bay.

Sediment chemistry data available since 1990 are described and presented in detail, including maps of sediment analytical data, in RIWP Volume 1 (Tierra, 2004). These data include analytical results from a collection of surface sediment and sediment core samples from a variety of sampling programs. The results (displayed on figures provided in RIWP Volume 1) offer insights into the extent of contamination in Newark Bay, and horizontal and vertical distributions of metals and organic chemicals.

In general, Newark Bay is contaminated by a wide variety of organic and inorganic chemicals. The primary classes of chemicals that have been detected to date include: metals/inorganic chemicals, PAHs and other semivolatile compounds, pesticides, PCBs, PCDD/Fs, and volatile organic compounds. A number of chemicals from each of these classes have been found at concentrations that are substantially elevated, relative to background concentrations for marine/estuarine systems, and available sediment quality benchmarks (USEPA 1998; NOAA 1995). These contaminants may be directly toxic to fish and wildlife that reside in or utilize Newark Bay, or may bioaccumulate in the food web and in humans that are exposed (see Section 3.2.3). The physicochemical properties of the major classes of contaminants are briefly discussed below. These properties affect the ability of these contaminants to become bioavailable and cause risk to humans and ecological receptors.

A number of organic and inorganic chemicals are known to bioaccumulate in tissue, and can subsequently be transferred through the food web, including to humans. These include organic compounds such as pesticides, PCBs, and PCDD/Fs, and select metals such as mercury, cadmium, lead, and selenium. The ability of these chemicals to bioaccumulate is regulated by their behavior in water and sediments, which in turn is regulated by a combination of their physicochemical characteristics and the fate and transport processes described in Section 3.1.

Many organic compounds (e.g., PAHs, pesticides, PCBs, and PCDD/Fs) and inorganic chemicals (e.g., mercury and lead) are known to be hydrophobic and non-polar and, therefore, tend to tightly bind to sediment particles. As such, their fate and transport in aquatic systems is regulated by the movement of sediment particles. Surface and subsurface sediments can be disturbed by physical processes (e.g., resuspension via wave action or currents or disturbance by ship keels/propellers) or by bioturbation, as depicted in Figure 3-1. Furthermore, sediment accumulation and vertical mixing controls the rate at which contaminants are being buried and, therefore, removed from potential human and ecological exposure.

The physical characteristics of the sediments and overlying water can also impact the movement of chemicals, and specifically metals, through the sediments. In anoxic environments, metals such as cadmium, copper, lead, and zinc typically exist as sulfide complexes and are relatively immobile. These metals can be mobilized through a change in redox potential (i.e., oxidation) and/or drop in pH. The latter is not likely to happen in an estuarine environment such as Newark Bay. In addition, microbial processes can transform mercury into methylmercury, which is substantially more bioavailable and toxic than its elemental form (Porcella, 1994). In estuaries such as Newark Bay, methylation processes tend to occur at higher rates in wetlands and inter-tidal mudflats under anaerobic conditions.

A comprehensive analysis of contaminant distributions in Newark Bay is not presented in this preliminary CSM. However, important observations that are relevant to the design of the Phase I SI presented in Section 6 are discussed below.

Overall, the existing sediment core data are inadequate to form broad conclusions about the vertical distributions of contaminants. The majority of the available samples are surface sediment grab samples. Further, a number of the available sediment core samples were collected very near to potential sources, and thus may not represent broader concentration patterns in their respective geomorphic areas. Many of the sediment core samples were discontinuous with depth, so conclusions regarding the shape of the profiles cannot be made. For example, USEPA analyzed subsections from the cores collected in 1992 and 1993 to depths ranging from approximately 0.5 to 1.2 m (1.6 to 3.9 ft) below the sediment surface. Core sections from the surface and bottom of each core were analyzed, as well as a subsection from mid-depth between these two samples. For most analytes and at most core locations, these data show maximum concentrations within 1 m (3.3 ft) of the sediment surface. Several cores collected in the Port Newark and Elizabeth Channels suggest continuous sources of PAHs, PCBs, or metals, and elevated concentrations at depth (relative to concentrations in surface sediments). In addition to elevated concentrations of PAHs, PCBs, and metals in 1992, data collected in the Elizabeth Channel in 1999, which followed a dredging event in 1998 (USACE, 2004b), continued to exhibit elevated concentrations. These data suggest either the presence of a continuing source in the vicinity of the Elizabeth Channel, or that transport processes within the Bay deposit PAH-, PCB-, or metal- containing sediment in this area.

Surface samples and sediment core samples collected along the Newark Bay shoreline suggest numerous potential localized sources of metals and organic chemicals. Evaluation of broader patterns of metals and organics suggests that large-scale concentration changes in the Bay in areas away from the shoreline are generally low; however, there are differences observed between the north and south Bay.

The distribution of certain organic chemicals reflects higher concentrations in the southern part of the Bay (near Arthur Kill) and in the northern part of the Bay (near the Passaic and Hackensack Rivers). DDT concentrations exhibit fairly low spatial variability among samples collected from the northern and middle reaches. The highest sediment DDT concentrations in the Bay and Kills system occur in Arthur Kill and southern Newark Bay, suggesting the possibility of either current or historical sources of DDT from Arthur Kill to Newark Bay in these areas.

Similar to DDT, concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and 2,3,7,8-tetrachlorodibenzo-p-furan (2,3,7,8-TCDF) also exhibit fairly low spatial variability throughout much of the Bay. The maximum concentrations of these chemicals have been observed in the Elizabeth and Port Newark Channels, although elevated concentrations also are observed in the northern part of the Bay and in the southern part of the Bay near Arthur Kill.

Bopp and Simpson (1991) collected several sediment cores from Newark Bay and its tributaries in 1985, which were sectioned and analyzed for select organic contaminants (PCDDs/PCDFs, PCBs, and pesticides) and radionuclides. No interpretation of the data were provided in this report, although each of the contaminant classes that were analyzed for were detected throughout the sediment cores at elevated concentrations (both spatially within the system, and temporally in the cores). Bopp et al. (1991) utilized a subset of the data collected in this study to evaluate 2,3,7,8-TCDD contamination in Newark Bay.

Suszkowski (1978) and Meyerson et al. (1981) measured the distribution of trace metals in the surface sediments of Newark Bay. Suszkowski assessed horizontal distributions of eight metals (mercury, cadmium, lead, copper, zinc, chromium, nickel, and arsenic) based on analysis of approximately 100 surface sediment samples. Enrichment factors were computed by dividing concentrations in each sample by “background” concentrations measured in two borings deeper than 5 m (16.4 ft) below the sediment surface. An isopleth map of the average enrichment factors for the eight metals in each sample showed the highest values in the southwestern part of the Bay (Suszkowski, 1978) adjacent to substantial industrial development. Other areas with elevated enrichment factors were the middle portion of the Bay east of Port Newark, and the northern portion of the Bay near the Passaic and Hackensack Rivers. NOAA (1984) evaluated distributions of metals in Newark Bay sediments using the Suszkowski (1978) and Meyerson et al. (1981) datasets and concluded that overall, the distributions of individual metals are similar to one another, showing elevated concentrations at the mouth of the Passaic, Hackensack, and Arthur Kill, likely associated with sources in these tributaries. Elevated concentrations in the center of the Bay were hypothesized to be due to preferential deposition. However, several notable discrepancies were found by Meyerson et al. (1981), who reported the highest lead value at the mouth of Morses Creek in Arthur Kill, while the highest concentration of zinc occurred at the mouth of Piles Creek, located farther downstream in Arthur Kill.

The study by NOAA (1984) included an analysis of radiochemistry profiles in sediment cores collected from throughout the Hudson-Raritan estuary system, including two cores from Newark Bay. In most areas of the Hudson-Raritan estuary, along the navigation channel and sub-tidal flats, radiocesium, radiocobalt, and plutonium have relatively low activity per gram of fine-grained sediment, and are usually found only in the upper 5 to 10 cm (2.0 to 3.9 inches) of sediment. In broad shallow areas and in protected coves along the estuary margins, radionuclide activities were relatively high, and measurable quantities were usually observed to sediment depths of 20 to 40 cm (7.9 to 15.7 inches) (NOAA, 1984). The two cores in the NOAA study collected from Sub-tidal Flats in Newark Bay show detectable ^{137}Cs to depths of about 10 cm and 20 cm (3.9 to 7.9 inches) below the sediment surface, which suggests deposition since the early 1950s. The ^{137}Cs time horizon, which represents when detectable concentrations first occurred in the environment, is generally accepted to be between 1950 and 1955 (Robbins and Edgington, 1976).

In summary, the available sediment data suggest that the sediments of Newark Bay are contaminated with a variety of chemicals that occur at elevated concentrations, relative to background for marine/estuarine sites and available sediment quality benchmarks. In addition, large-scale concentration patterns exist within areas of elevated contaminant concentrations occurring near Arthur Kill, in the middle portion of the Bay (i.e., the Port Elizabeth and Port Newark area), and near the Passaic and Hackensack Rivers' mouths. Available data also indicate areas of high concentrations of select compounds along the shoreline, potentially associated with source areas. The available sediment core radiochemistry profiles and historical bathymetric comparisons suggest that in the large Sub-tidal Flat areas, deposition rates are very low, and that sediments deposited since 1954 are likely contained within the top few feet of sediment.

3.2.3 Human and Ecological Exposures

Figures 5 and 6 of the Newark Bay Study Draft Pathways Analysis Report present the likely routes of exposure to contaminants for humans and ecological receptors in Newark Bay (Battelle, 2005). These figures represent a subset of the overall fate and transport processes that are presented in Figure 3-1. They depict the specific pathways of potential exposure for humans and ecological receptors from water and sediments, including an indirect exposure to groundwater via potential seepage into Inter-tidal Areas.

The primary human exposures are likely through contact with water and sediment, as well as from recreational angling (i.e., fishing and crabbing) and any subsequent ingestion of fish and/or blue crabs. Ecological exposures include direct contact with water and sediments for ecological receptors, and food web interactions (i.e., bioaccumulation). The specific exposure of each group of organisms (i.e., invertebrates, fish, and/or wildlife) is dependent on their specific trophic level and individual feeding strategies. These will determine the relative importance of contact – versus ingestion-based exposure risk.

4. Processes Used to Achieve RI Goals

This section provides an overview of the processes that will be used to achieve the three RI Goals (including the associated objectives) outlined in Section A of the SOW. The three RI-related goals (and associated objectives) are as follows:

- *RI Goal 1*: Determine the horizontal and vertical distribution and concentration of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals for the Newark Bay Study Area sediments. This information is necessary to:
  - determine concentration gradients and, based on the gradients, identify hot spots for potential short-term action;
  - identify potential exposure concentrations through the food chain for human and ecological receptors; and
  - evaluate prospective remedial alternatives (SOW Section A.1).

- *RI Goal 2*: Determine the primary human and ecological receptors (endpoints) of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals contaminated sediments in the Newark Bay Study Area. This information is necessary to:
  - identify potential impacts to (a) humans and (b) the ecology both directly (i.e., species sustainability) and indirectly (i.e., food web impacts);
  - identify receptors of greatest concern;
  - select and/or develop appropriate site-specific biological tests and contaminant uptake evaluations; and
  - identify human health and ecological risks and establish appropriate action levels (SOW Section A.2).

- *RI Goal 3*: Determine the significant direct and indirect continuing sources of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals in the Newark Bay Study Area (SOW Section A.3).

Tierra's main focus of this RIWP was RI Goal 1. However, Tierra has agreed to obtain a limited set of data that will be useful in ultimately addressing risk assessment and source identification issues.

In developing this IWP, USEPA's Guidance for Data Quality Objectives (USEPA, 2000a) was utilized to design a meaningful and scientifically robust sampling program. As described in Section 4.1, the results of this seven-step data quality objectives (DQO) process were used to develop the ultimate scope of work. The proposed work scope is provided in Sections 4.2 through 4.4.

4.1 Design of Sampling Program

USEPA's Guidance for Data Quality Objectives (USEPA, 2000a) provides a seven-step DQO process useful in designing sampling programs. Questions that are fundamental to formulating the DQOs include:

Step 1 - What problems will be studied and what are the objectives of the project?

Step 2 - What specific decisions must be made or questions resolved, on the basis of the data to be collected?

Step 3 - What types of data are required, how are the data to be obtained and managed, and how will they be used?

Step 4 - What are the spatial limits and what are the temporal limits?

Step 5 - How will the data, once collected, be synthesized and interpreted in order to make a decision?

Step 6 - Specify tolerance limits on decision error - what are the acceptable performance limits and constraints that will limit performance?

Step 7 - Optimize the design for obtaining data - what is the optimum approach in terms of the cost-benefit ratio for meeting DQOs?

In addition to specific quantifiable objectives, use of this DQO methodology requires that the variability of data be understood to evaluate the trade-offs between uncertainty (confidence levels) and sampling intensity (USEPA, 2002b). Based on a review of the existing Newark Bay data (see RIWP Volume 1 [Tierra, 2004]), there currently exists a limited amount of site-specific historical data and information available to optimize a comprehensive sampling design in full accord with the seven steps outlined in this process. Existing uncertainties limit the ability to formulate the principal study questions with the degree of specificity required.

To overcome these limitations, an iterative (or phased) sampling effort is planned. Results of an initial sampling phase can serve to better formulate subsequent sampling activities. USEPA guidance encourages the use of a phased approach, "…especially at complex contaminated sediment sites…" (USEPA, 2002a). By proceeding in phases, the overall sampling plan can rapidly adapt to new data, considering both scientific needs and logistical constraints, and can ultimately serve to accelerate the progress of subsequent stages of the program.

As briefly described in Section 1.1 of this IWP, sampling will be conducted in two discrete phases. As further described in this IWP, the proposed extent of sampling/analyses of the Phase I Program will generate valuable insight into the distribution of COPCs in sediments. When combined with the historical sediment information, this new data set should form a basis for establishing future sampling strategies needed to meet RI Goal 1. This program will also provide preliminary data for the risk assessment (RI Goal 2) and source identification (RI Goal 3) processes.

As a result of the existing uncertainties and limitations related to the historical dataset, the following discussion of the DQO process is primarily qualitative.

4.1.1 DQO STEP 1 – STATE THE PROBLEM

Section 1 of this IWP contains a discussion of the regulatory background of this sampling program. As described, the work is being conducted as part of an RI/FS for Newark Bay under CERCLA. More specifically, these activities are being undertaken to satisfy the AOC, which identifies three specific goals:

- Determining the horizontal and vertical distribution and concentration of specified contaminants for the Newark Bay Study Area sediments.
- Determining the primary human and ecological receptors of the specified contaminants in the Newark Bay Study Area sediments.
- Determining the significant direct and indirect continuing sources of the specified contaminants in the Newark Bay Study Area.

Section 2 of this IWP provides a description of Newark Bay, including such characteristics as bathymetry, surface water hydrology, and historical and current contaminant sources. This description is meant to establish important features and/or characteristics of the Bay that should be considered in designing the sampling program.

Section 3 contains a discussion of the preliminary CSM. The preliminary CSM was developed based on the limited historical data and information available to identify some general, broad relationships among types and concentrations of contaminants, potential sources/pathways, and potential targets or receptors. The preliminary CSM provides a baseline to which sampling results will be compared. This will allow the CSM to be revised, as necessary, as new information is obtained.

Work performed under this RIWP will contribute to the completion of the RI/FS for the Newark Bay Study Area, which includes a human and ecological risk assessment, and the identification of on-going sources. Ultimately, this work will culminate in the selection of the most appropriate remedial action(s) for the Newark Bay Study Area.

In support of this overall problem statement, and given the current, relatively limited knowledge base for this Study Area, the Phase I program has been designed to obtain reconnaissance data for each of the three AOC-related goals.

A project schedule for completion of Phase I is provided in Section 10. As shown in Figure 10-1, the field work is scheduled to be completed approximately 90 days following Work Plan approval. The project team is described in Section 5 of this IWP, including respective QA responsibilities.

4.1.2 DQO STEP 2 – IDENTIFY THE DECISION

As indicated above, the overall objective of the work is to support completion of an RI/FS.. While still early in the process, it is likely that the FS will identify the following technologies (either alone or in combination) as potential remedial actions:

- No Action (baseline)
- Monitored Natural Attenuation
- Capping
- Sediment Removal
- Ex-situ Sediment Management
- In-situ Sediment Management

In consideration of the RI/FS process, the Phase I program will focus on specific objectives that, when addressed, will lead to the consideration and design of subsequent investigations. Each component, with the associated Phase I objectives, is defined further below.

RI Goal 1 (Nature and Extent of Sediment Contamination)

- Confirm the presence/extent of individual geomorphic areas.
- Estimate the approximate depth of the 1940 sediment horizon in the various geomorphic areas.
- Better understand broad constituent patterns of constituents in both the surface and subsurface sediments, and attempt to preliminarily identify “hot spots” through statistical analyses (e.g., Rosner’s test [USEPA, 2000b]).
- Confirm that the current analytical suite is appropriate for the various geomorphic areas.
- Determine data needs for Phase II.

RI Goal 2 (Risk Assessment)

- Preliminarily characterize (through sediment sampling) the nature of contamination within select ecologically sensitive inter-tidal mudflats.
- Determine the depth of the BAZ within various geomorphic areas of the Phase I Study Area.

RI Goal 3 (Source Identification)

- Gather information to be used in identifying on-going sources to the Bay including identification of sampling locations for future phases of work.
- Confirm (through sediment sampling) impact to select areas of the Newark Bay and the Hackensack River believed to be affected by historical and/or current discharges.

Overall, the Phase I Program will provide the data necessary to develop a more quantitative approach in designing Phase II, especially as it relates to DQO Steps 3 and 6.

4.1.3 DQO STEP 3 - IDENTIFY INPUTS TO THE DECISION

The following historical information was used in developing the current CSM (Section 3), and in designing the initial phase of work:

- Historical data summarized in RIWP Volume 1 (Tierra, 2004) regarding the chemical and geotechnical properties of the Newark Bay Study Area sediments;
- Historical bathymetric records including those related to dredging, infilling and other anthropogenic activities that may influence bathymetry;
- Historical and current studies of sediment transport and deposition within the Newark Bay Study Area, including previous radiochemical dating; and
- Historical and current hydrologic and hydrodynamic data including river flow and tide data.

In combination with the Phase I data that are ultimately collected, this historical information will be valuable in establishing the subsequent phase of work.

4.1.4 DQO STEP 4 – DEFINE THE STUDY BOUNDARIES

As described in AOC Paragraph 2.r, the Newark Bay Study Area includes Newark Bay and portions of the Hackensack River, the Arthur Kill, and the Kill van Kull (Figure 1-1). As described in Section 2.1.1, the area of focus for the Phase I Program (i.e., Phase I Study Area) is defined to include Newark Bay bounded by the following landmarks:

- the LPRRP downstream boundary;
- the Conrail Bridge at the Hackensack River;
- the Bayonne Bridge; and
- the Goethals Bridge.

Based on these boundaries and the shorelines of Newark Bay, this area encompasses a total of approximately 6.6 square miles. These boundaries will be reevaluated (using the results of Phase I) prior to conducting any future sampling activities.

The Source Identification Program (RI Goal 3) will be conducted within the Phase I SI Study Area, but will also extend into the major tributaries described in this section (i.e., Passaic River, Hackensack River, Arthur Kill, and Kill van Kull), including smaller direct and indirect tributaries. In addition, certain upland areas surrounding Newark Bay will be subject to this work, depending on their relevance as areas of potential continuing sources. For purposes of Phase I, select source identification samples will be collected from Newark Bay and portions of the Hackensack River.

To facilitate the collection and subsequent interpretation of the Phase I data, the Phase I Study Area has been divided into eight major geomorphic areas (Section 3 of this IWP):

- Southern Navigation Channels (South of Port Newark);
- Northern Navigation Channels (North of Port Newark);
- Port Channels;
- Transitional Slopes;
- Sub-tidal Flats;
- Inter-tidal Areas;
- CDF; and
- Industrial Waterfront Areas.

The vertical boundaries for the Phase I Program are to include depths that define the extent of chemicals or provide historical context to chemical deposition patterns within the sediment bed. In certain areas (specifically dredged channels), boundaries may be defined by the extent of historical dredging elevations (or beyond). In addition, sediment boundaries may extend to a depth sufficient to encompass sediments that are, or may become, bioavailable, and that may be subject to scour transport and redeposition.

As appropriate, the temporal boundaries are to include the historical data presented in RIWP Volume 1 (Tierra, 2004) and the preliminary CSM (Section 3 of this IWP).

4.1.5 DQO STEP 5 – DEVELOP A DECISION RULE

The following questions present the decision rules that will be used to meet the objectives presented in Step 2.

RI GOAL 1 (Nature and Extent of Sediment Contamination)

Confirm the presence/extent of individual geomorphic areas

- Is the areal extent of the defined geomorphic areas appropriate given the stated objectives?
- Does stratification by geomorphic area reduce unexplained horizontal or vertical variability in the data?
- Are deposition rates or other properties different among geomorphic areas?
- Do observed differences in geomorphic area properties lend themselves to different approaches to data collection and data needs in Phase II in support of developing remedial alternatives?

Estimate the approximate depth of the 1940 sediment horizon in various geomorphic areas

- Are current estimates of depositional rates and the approximate depth of the 1940 horizon accurate?

Better understand broad constituent patterns in both the surface and subsurface sediments, and attempt to preliminarily identify "hot spots" through the use of statistical tests.

- Are there broad spatial patterns of COPCs in the Phase I Study Area?
- Using outlier tests and cluster analyses, do hot spots exist in the Phase I Study Area, and to what extent?
- Do graphic or numerical interpretations of the collected data begin to support the correlation or association between select COPCs or properties?
- Are there identifiable temporal trends in vertical concentrations?

Confirm that the current analytical suite is appropriate for the various geomorphic areas

- Is the complete list of target analytes appropriate for all geomorphic areas?
- What detection and/or reporting limits are appropriate for the study objectives?

RI GOAL 2 (Risk Assessment)

Preliminarily characterize (through sediment sampling) the nature of contamination within select ecologically sensitive inter-tidal areas

- Do COPCs exist in the identified Inter-tidal Areas, and if so, to what extent?
- What is the general presence and condition of the local benthic community?
- Is the assumed BAZ depth of 6 inches appropriate for the Phase I Study Area?

RI GOAL 3 (Source Identification)

Gather information to be used in identifying on-going sources to the Bay

- Is the information collected during research of POTWs, tributaries, and point sources (e.g., outfalls, historical discharge records, spills) sufficient to begin identifying the on-going sources to the Bay?
- What sources are priorities for subsequent investigation?

Confirm (through sediment sampling) current and historical discharges impacting select areas of the Bay

- What constituent sources to the Bay currently exist?
- What constituent sources may have existed in the past?
- To what degree do/did such sources affect the Bay?

4.1.6 DQO STEP 6 - SPECIFY LIMITS ON DECISION ERRORS

Since the primary objective of Phase I is to collect sufficient data to design a subsequent collection/sampling program, the consequence of decision errors made during the initial phase is somewhat lessened. As noted in the reference (USEPA, 2000a), "Often the decisions that are made early in the project will be preliminary in nature; they might require only limited planning and evaluation effort." However, as the study nears conclusion and the consequences of making a decision error become more critical, the level of effort needed to make a decision generally will become greater.

Specific hypotheses typical of remedial projects, such as direct comparison to an action level, are not being evaluated in the Phase I sampling. In the absence of defined decision tolerance limits, the sampling design should still strive to identify possible sources of error and minimize them, to the extent practical. Several types of errors that may be encountered include:

Sediment Sampling

Measurement errors are the result of imperfection inherent in the measurement and analysis of the samples. Both random and systematic errors can be introduced during the physical collection of the sample, sample handling, sample analysis, and data handling.

Errors introduced through these steps will be controlled by preparing and following standard operating procedures (SOPs), and establishing appropriate controls for data quality (as outlined in Section 5). These controls apply to field procedures (e.g., adherence to SOPs, field equipment calibration, equipment, field duplicates), laboratory analytical errors (e.g., calibration standard, interval standard and surrogate recoveries, lab control sample), and data validation.

Sample design error is the result of the inherent variability of the sampled population over space and time, the sample collection design, and the number of samples available upon which to base the decision. Since it is impossible to sample every inch of the Bay, there is always a possibility that some feature of the natural variability is missed. Sampling design error can increase the chance for misrepresenting the natural variability by random error (imprecision) or systematic error (bias) in sampling.

As the number of samples controls how well the population is characterized,. use of the DQO process requires that the variability of data be understood to evaluate the trade off between uncertainty (confidence limit) and sampling intensity. By using a phased approach, Phase I samples will provide the necessary sample population to statistically test hypotheses associated with the design of Phase II sampling (i.e., tolerance limits).

Additionally, the sampling has been segregated into various regions based on geomorphic areas to address part of the inherent variability present in Newark Bay. This stratification will reduce the overall unexplained variability in the data, and increase the power of subsequent statistical analysis.

Bathymetry Program

For bathymetric surveys, errors may be introduced during the measurement process itself, reduction of the data, or interpretation of the results. The measurement and data reduction errors can be controlled by preparing and following SOPs, and by establishing an accuracy standard for the data that meets or exceeds the Class I USACE hydrographic standard (USACE, 2002).

Bathymetric survey design errors can be minimized by developing a program to meet the data needs of the project. For example, the survey tracklines can be more widely spread should the primary goal be verification of geomorphic areas, and not representation of precise depth at a horizontal scale of meters or even tens of meters. In select areas where data needs are greater (near shoreline structures bridge crossings, breaks in navigation channel banks), more closely spaced tracklines can be used.

BAZ Investigation

As with the bathymetric survey, errors may be introduced during the measurement process itself or interpretation of the results. The measurement errors can be controlled by preparing and following SOPs, and collecting duplicate SPIs and grab samples. Additionally, these complimentary activities (i.e., SPI and grab samples) can minimize interpretation errors by providing data that are both similar and independent.

4.1.7 DQO STEP 7 – OPTIMIZE THE DESIGN FOR OBTAINING DATA

Based on Steps 1 through 6, the Phase I program was developed to generate data that are expected to satisfy the DQOs. The following subsections present the Phase I Scope of Work for each RI Goal. In addition, Table 4-1 provides a high level summary of the proposed scope and associated data uses.

4.2 RI Goal 1: Determine the Horizontal and Vertical Distribution and Concentration of COPCs in Newark Bay Study Area Sediments

The intent of this RI goal is to characterize the horizontal and vertical distribution and concentration of COPCs in Newark Bay Study Area sediments. Through this process, areas that may be considered as “hot spots” are to be identified, and potential remedial alternatives developed and evaluated. In addition, the SOW indicates that potential human and ecological exposure concentrations should be identified as part of this work.

SOW Section B.3.b.i requires that the program used to meet this RI goal is to include sediment cores collected to the maximum time-stratigraphic depth corresponding to the year 1940, determined by historical radiochemistry or bathymetric data. This same SOW section specifies that all cores will be analyzed for both sediment chemistry and radiochemistry dating. A sample will also be collected from the BAZ.

Given these requirements, the preliminary CSM presented in Section 3, and the DQO process, the following provides a description of the Phase I SI Program, and how data generated from it will be used to meet RI Goal 1.

4.2.1 Phase I Sediment Investigation (SI) Program

Given the set of DQOs identified in Section 4.1, the Phase I SI generally will consist of collecting a series of sediment cores from seven principal geomorphic areas identified in Section 3, including:

- Southern Navigation Channels (South of Port Newark);
- Northern Navigation Channels (North of Port Newark);
- Port Channels;
- Transitional Slopes;
- Sub-tidal Flats;
- Inter-tidal Areas; and
- Industrial Waterfront Areas.

The Navigation Channels were segregated into northern and southern units due to the differences in historical dredging activities. While the Southern Channels have been extensively dredged over the past several years (including current activities), material from the Northern Channel has not been removed since 1989. This temporal difference creates divergent conditions, and therefore produces two varying units for the purposes of sampling.

The CDF is the only geomorphic area not included in the initial sampling program since it will be managed in accordance with USACE (1997a), Knoesel et al. (1998), and Matthew et al. (1999). Therefore, this planned maintenance and monitoring program negates the need to collect investigative samples as part of this IWP.

For the seven geomorphic areas included in the Phase I SI Program, a total of 69 locations will be cored and sampled for various analytical chemistry, radiochemistry and geotechnical parameters. The chemical analyses incorporated into the Phase I SI Program are as follows:

- Pesticides and Aroclor PCBs
- Semivolatile Organics
- Volatile Organics
- Metals
- Cyanide
- Organotins
- PCB Congeners and Homologues
- Chlorinated Herbicides
- Dioxin/Furan Isomers
- Total Extractable Petroleum Hydrocarbons (TEPH)

Once collected, this analytical data set will serve to provide representative spatial data of sediment chemistry in Newark Bay, allowing large-scale gradients and likely “hot spot” areas to be defined.

The following radiochemistry analyses will also be performed on a limited number of samples collected during the Phase I SI Program:

- Beryllium-7 (^{7}Be) (top 1-inch segment only)
- Cs-137
- Lead-210 (Pb-210)

Radiochemistry data for the targets listed above will be used to estimate the appropriate depth of the 1940 sediment horizon, and verify the depth to which sediment cores need to be collected in future sediment investigations. Grain size and bulk density data will be collected to provide an understanding of the general physical characteristics of the Bay.

The Phase I SI will also include a bathymetric survey, which will be used to:

- verify or refine the initial delineation of the geomorphic areas; and
- assist the sediment sampling crew in determining the extent of the Transitional Slopes for use in collecting the associated cores.

Finally, the Phase I SI will include a BAZ investigation. This work will assist in quantifying the depth of the BAZ in the Phase I Study Area using SPI and grab sample information.

Further details pertaining to the Phase I SI Program are provided in Section 6.

4.2.2 Phase II SI Program

In assessing and evaluating the Phase I SI data, it will be important to formulate specific objectives for the subsequent sampling phase. The Phase II objectives should consider the following elements, at a minimum:

- large-scale COPC concentration differences across broad areas of the Bay;
- differences in sediment COPC concentrations within geomorphic areas;
- possible identification of hot spots;
- areas/volumes of impacted sediments for evaluation of potential remedial alternatives and scenarios; and
- additional geotechnical characteristics of sediments that may require remediation.

While it is recognized that this list is not exhaustive, it provides a general vision for the Phase II SI Program. For purposes of implementing this subsequent sampling event, this IWP will be amended, as necessary, and submitted for USEPA review and approval according to AOC Paragraph 89.

4.2.3 Reporting

The data and information collected as part of the Phase I SI will be validated and managed according to this IWP. As stated in the AOC, the data will be made available to USEPA in an electronic format upon request.

Once validated, the Phase I data will be merged (to the extent possible) together with historical information and evaluated for purposes of designing the subsequent phase of sampling. As part of this evaluation process, the data will be graphically presented to help identify overall trends. Various statistical analyses will also be performed in characterizing the nature and extent of contamination.

Ultimately, the data will be incorporated into the Newark Bay RI Report.

4.3 RI Goal 2: Determine the Primary Human and Ecological Receptors of COPCs in the Newark Bay Study Area

SOW Section B.3.b.ii indicates that USEPA will perform a Human and Ecological Risk Assessment for purposes of meeting RI Goal 2, and to do so, will develop a Risk Assessment Plan for the Newark Bay Study Area. Using this Plan, Tierra will collect the requisite data for USEPA's use. These data will also be incorporated and considered in the Newark Bay RI Report.

At the time of this IWP submission (September 2005), USEPA has not provided Tierra with the Risk Assessment Plan, however, the data collected as part of the Phase I SI Program will be useful for developing an initial understanding of the COPCs that may affect the ecological health of the Bay. Of the 69 cores proposed under the Phase I SI Program, six will be collected from Inter-tidal Areas to preliminarily characterize the nature of contamination within these ecologically sensitive locations. Additionally, a BAZ investigation (as described earlier) will be conducted at 14 locations within Newark Bay to determine the approximate depth of biological activity.

These data will be reported consistent with Section 4.2.3.

4.4 RI Goal 3: Determine Significant Direct and Indirect Continuing Sources of COPCs to Newark Bay Study Area Sediments

SOW Section B.3.b.iii specifies that RI Goal 3 consists of two discrete tasks:

- modeling of the fate and bioaccumulation of COPCs, including the collection of data according to a plan to be developed by USEPA that will include water quality, sediment, and biota data, at a minimum; and
- characterizing storm water and CSO discharges into the Newark Bay Study Area, consistent with the characterization activities associated with the LPRRP.

As prescribed in the SOW, USEPA is responsible for implementing the first task listed above. To guide this effort, USEPA will develop a Modeling Plan. Similar to RI Goal 2, once the Modeling Plan is complete, Tierra will collect the specified data. At the time of this IWP submission (September 2005), USEPA has not provided Tierra with the Modeling Plan, and therefore it is not addressed herein.

Responsive to the second task, this IWP describes the process to be followed to identify and characterize (where appropriate) continuing sources to the Newark Bay Study Area. As discussed in Section 2.1.1, the investigation area will include Newark Bay and its tributaries, and will be conducted in phases. The first phase, known as the Source Identification Program, will be useful in identifying and ranking the relative significance of the various continuing sources, and in determining which should be considered for future sampling efforts. Specifically, the Source Identification Program will consist of field reconnaissance and literature research efforts aimed at better understanding the following:

- waterfront - located sources;
- POTW, CSO, and SWO sources; and
- tributary sources.

The majority of the actual sampling activities, known as the Source Sampling Program, will not occur until information obtained from the Source Identification Program is evaluated. However, as described further herein, data collected as part of the Phase I SI Program (see Section 4.4.2) will be used to confirm the impact of current and historical discharges in select areas of the Bay. These data, along with information collected as part of the Source Identification Program, will be used in developing the remaining sampling activities.

4.4.1 Source Investigation Program

4.4.1.1 Investigation of Waterfront-Located Sources

This task will focus upon the identification and assessment of sources (including specific discharge outlets) from waterfront-located operations. In particular, these efforts will identify the following:

- permitted and un-permitted sources with direct or indirect discharges to Newark Bay;
- potential groundwater discharges to Newark Bay; and

- spills, leaks, and other discharge events impacting Newark Bay.

The waterfront locations of interest will include, but will not be limited to, the following areas:

- City of Newark, Essex County, NJ;
- City of Elizabeth, Union County, NJ;
- Town of Kearny, Hudson County, NJ (including South Kearny);
- City of Jersey City, Hudson County, NJ;
- City of Bayonne, Hudson County, NJ; and
- City of Staten Island, Richmond County, NY.

This investigation will include boat-based and land-based tours of the waterfront areas. In addition, research will be conducted to compile information relative to the topical areas listed previously. Numerous public institutions (e.g., libraries, municipalities, internet) will be utilized to complete the research task.

4.4.1.2 Investigation of POTW, CSO, and SWO Sources

Information on POTWs currently serving Newark Bay will be compiled during this task. Treatment plant outfalls, CSO, and SWOs known to be associated with these POTWs will be identified. In particular, the following information will be developed:

- determine the infrastructure and operation of the POTW systems;
- identify outfalls for the POTW systems;
- identify CSOs and their collection areas;
- identify SWOs for the POTW systems;
- identify ownership of sanitary, CSO, and SWO outfalls for each POTW system;
- obtain current and historical discharge records for these CSOs and SWOs, including, where available, details regarding the dates, volume, and characterization of discharges;
- identify permitted and un-permitted sources that discharge to the POTW, CSO, and SWO systems; and
- identify spills, leaks, and other discharge events to the Bay via the POTW, CSO, and SWO systems.

The POTWs that will be the focus of this task include, but are not limited to, the following:

- City of Bayonne
  Bayonne, Hudson County, NJ
  NJPDES # NJ0109240

- City of Elizabeth
  Elizabeth, Union County, NJ
  NJPDES # NJ0108782

- City of Jersey City Sewerage Authority
  Jersey City, Hudson County, NJ
  NJPDES # NJ0108723

- Joint Meeting of Essex & Union Counties
  Elizabeth, Union County, NJ
  NJPDES # NJ0108740
  NJPDES # NJ0024741

- Town of Kearny
  Kearny, Hudson County, NJ
  NJPDES # NJ0111244

- City of Newark
  Newark, Essex County, NJ
  NJPDES # NJ0108758

- City of New York
  Port Richmond Water Pollution Control Plant
  Staten Island, Richmond County, NY
  SPDES # NY0026107

- Passaic Valley Sewerage Commission
  Newark, Essex County, NJ
  NJPDES # NJ0108707
  NJPDES # NJ0021016

As a first step in this process, sources located in the given collection areas of the POTW, CSO, and SWO systems will be identified. Once this information is obtained, a land-based tour of the POTWs, CSOs, SWOs, and their associated collection areas will be conducted.

To supplement the field work, research will be conducted to compile information on the POTWs, CSOs, and SWOs from publicly available resources. The research will obtain relevant information/data associated with the key elements of this task listed at the beginning of this subsection.

4.4.1.3 Investigation of Tributary Sources

This investigation will focus on tributary waterways discharging (directly or indirectly) into Newark Bay, and will compile the following information:

- permitted and un-permitted sources (with direct or indirect discharges and outlets) to the tributary waterways and Newark Bay;
- sources with potential groundwater discharges impacting Newark Bay; and
- spills, leaks, and other discharge events impacting Newark Bay.

The tributaries of particular interest include, but are not limited to, the following (Figure 1-1):

<u>Newark Bay Waterway and Tributaries</u>

- Peripheral Ditch - Newark, Essex County, NJ;
- Piersons Creek - Newark, Essex County, NJ;
- Plum Creek - Newark, Essex County, NJ;
- Port Elizabeth - Elizabeth, Union County, NJ; and
- Port Newark - Newark, Essex County, NJ.

<u>Arthur Kill Waterway and Tributaries</u>

- Arlington Marsh - Staten Island, Richmond County, NY;
- Arthur Kill - Elizabeth and Carteret, Union County, NJ;
- Elizabeth River - Elizabeth, Union County, NJ;
- Mariners Marsh - Staten Island, Richmond County, NY;
- Morses Creek - Linden, Union County, NJ;
- Old Place Creek - Staten Island, Richmond County, NY; and
- Piles Creek - Linden, Union County, NJ.

<u>Kill van Kull Waterway and Tributaries</u>

- Kill van Kull - Bayonne, Hudson County, NJ; and Staten Island, Richmond County, NY; and
- Platykill Creek - Bayonne, Hudson County, NJ.

Hackensack River Waterway and Tributaries

- Hackensack River - Kearny and Jersey City, Hudson County, NJ

Passaic River Waterway and Tributaries

- Franks Creek - Kearny, Hudson County, NJ;
- Harrison Creek - Newark, Essex County, NJ;
- Lawyers Creek - Newark, Essex County, NJ; and
- Passaic River - Newark, Essex County, NJ; and Kearny, Hudson County, NJ.

The list of tributaries provided above was compiled after a review and analysis of:

- the geographic area of the Lower Passaic River north to its confluence with Franks Creek;
- the geographic area of the Lower Hackensack River north to the upper boundary of Jersey City;
- the geographic area of the Arthur Kill south to the Tremley Point section of Linden, NJ; and
- the area of the Kill van Kull east to its confluence with New York Bay.

It is possible that the tributaries of interest may change after further review of public records and/or reconnaissance information.

Similar to other source identification tasks, this investigation will include both boat-based and land-based tours of the identified tributary areas. In addition to the field survey, research will be conducted on the tributary waterways and their contributing areas using publicly available resources (as described previously for other source identification tasks).

4.4.1.4 Investigation of Newark Bay

As part of this overall source investigation, surveys (by boat and land) of Newark Bay's waterfront areas will be conducted. To the extent practicable, the surveys will also extend into the tributaries of interest.

4.4.1.5 Reporting

The information gathered during this Source Identification Program will be compiled into a written report, which will be structured to include the following topics:

- methodology used to investigate the waterfront areas and sources;
- methodology used to investigate POTWs, CSOs, and SWOs;
- methodology used to investigate tributaries and tributary sources;
- methodology used to preliminarily rank the potential sources identified;
- summary of findings; and
- relevant documentary evidence compiled in the course of the investigation.

This report will be submitted as part of the Source Sampling Work Plan, as described further below.

4.4.2 Source Sampling Program

Following assessment of the Source Identification information, Tierra will develop a Source Sampling Work Plan which will document the field sampling needed to identify continuing direct and indirect sources to Newark Bay. The criteria used to rank potential sources identified during the Source Identification Program will be described in this work plan; however, major elements of consideration will likely include:

- Character and nature of documented discharges;
- Frequency and/or duration of documented discharges;
- Existence of present-day and/or historic discharge mechanisms; and
- Character of multi-source discharge points, such as CSOs, to include demographics and the existence of industrial sources.

In addition, information gathered from the Phase I SI sampling activities will also be useful in this regard. Specifically, nine of the 69 cores proposed under this Phase I SI Program (i.e., Industrial Waterfront Areas) will provide data from areas expected to be impacted by historical and/or on-going sources to the Bay. This information will feed into the development of the Source Sampling Work Plan.

According to SOW B.3.b.iii.(2), this identification work will be conducted in a manner consistent with the LPRRP. Given this, and given the fact that the LPRRP CSO Sampling Program is still under development, the timing of collecting Newark Bay CSO samples is unclear. Ultimately, data obtained as part of the Source Identification and Source Sampling Programs (together with USEPA's Modeling Plan) will be incorporated into the Newark Bay RI, and will be used in meeting RI Goal 3.

5. Project Management and Quality Systems

To implement a high quality sampling/analysis program, a well-developed project management system is critical. This includes selecting a qualified project team and developing common processes and protocols for managing important aspects of the project. This section presents a discussion of these topics to demonstrate that the IWP serves this purpose.

5.1 Project/Task Organization

The organizational and project management structure of the Phase I SI and Source Identification Project Team (herein referred to as the Project Team) is presented in this subsection. In accordance with Section B.3.d of the SOW, the team members identified include major contractors (and subcontractors) who will implement this IWP. This section also serves to identify key individuals expected to participate in the work, and describes each person's respective responsibilities. Qualification materials for the contractors and subcontractors discussed (including resumes of key personnel) are provided in Appendix A.

Figure 5-1 provides a Project Organization chart that illustrates the organizational structure associated with this IWP, and the relationships that exist among the various parties. While Tierra expects that the overall project organization structure and associated Project Team will remain consistent throughout the Phase I SI and Source Identification activities, it is possible that changes could occur. In such cases, USEPA will be advised of such changes according to Paragraph 89 of the AOC.

Only those RI activities associated with this IWP are addressed in this section. Project personnel associated with future RI work will be addressed in subsequent work plan addenda/revisions. In addition, as described in Paragraph 45 of the AOC, FS-related activities will be addressed in the FS Work Plan (FSWP).

5.1.1 Project Management

The overall Project Management Team will consist of USEPA Region 2 and Tierra personnel, with Tierra maintaining overall technical responsibility for conducting this IWP. Each personnel group is briefly described below.

5.1.1.1 USEPA Region 2

USEPA Region 2 will serve as the lead Agency on this project, and Ms. Elizabeth Butler will serve as Remedial Project Manager (RPM). The RPM will monitor the overall progress of the work. Additional responsibilities and duties of the RPM are outlined in Section IX of the AOC, and include (without limitation) the following:

- authorization to cease any activity in the Newark Bay Study Area that may endanger public health or the environment;
- authorization of field modifications to the studies, designs, techniques, or procedures undertaken as part of the project; and
- assignment of other representatives to serve in his or her capacity for the oversight of daily operations.

5.1.1.2 Tierra

For Tierra, Mr. Richard McNutt will serve as the Facility Coordination (FC), and Mr. Clifford Firstenberg will serve as Alternate FC. The FC will be responsible for implementing the RI/FS Program. This individual will also have the authority to commit the resources necessary to meet project objectives and requirements. The FC's primary function is to ensure that technical, financial, and scheduling objectives are achieved successfully. In addition, the FC will serve as the primary point of contact and control for matters concerning the project. The Alternate FC's responsibilities are supplemental and auxiliary to the FC.

Additionally, Mr. Paul Bluestein will serve as Tierra's Field Manager. He will be responsible for coordinating and overseeing field activities, and will work closely with the various subcontractors.

Mr. Merton M. Skaggs, Jr., P.E., has been identified as the Project Quality Assurance Officer (QAO). He is independent of the entity generating the data, and will be responsible for the overall QA/QC of the various investigations. Mr. Skaggs will lead the planning, documentation, coordination, and assessment of the QA/QC system established in this IWP for Tierra. Appendix A provides Mr. Skaggs' qualifications.

5.1.2 IWP Implementation

The organizations and individuals responsible for designing and implementing the Phase I SI and Source Identification Programs associated with this IWP are described in this section.

5.1.2.1 Lead Consultant/Field Oversight/Core Processing

Blasland, Bouck & Lee, Inc. (BBL), Syracuse, New York, will serve as Tierra's Lead Consultant for the IWP. In this role, BBL will assist Tierra in the overall planning and coordination of the IWP work efforts. Mr. Robert Romagnoli will serve as Project Manager (PM) for BBL. Appendix A provides BBL's qualifications, along with Mr. Romagnoli's resume.

The BBL PM will be responsible for providing overall technical support on the project, and will serve as a key contact to the Project Management Team. This individual also will be responsible for directing BBL work efforts and reviewing work products including memoranda, letters, and reports transmitted from BBL.

BBL will provide oversight for all field activities, and will also be responsible for core/sample processing. In addition, BBL will provide data management services for the program.

5.1.2.2 Sediment Collection/Bathymetry/BAZ Contractor

Sediment collection, bathymetry, and BAZ investigation activities will be provided by Ocean Surveys, Inc. (OSI), Old Saybrook, Connecticut, with Mr. George Reynolds acting as PM. Dr. Robert Diaz (R.J. Diaz & Daughters) will assist OSI in evaluation of the BAZ information. Resumes for both Mr. Reynolds and Dr. Diaz are provided in Appendix A.

5.1.2.3 Laboratories

Various laboratories will be used for analytical chemistry and radiochemistry analyses as part of the Phase I SI Program. Laboratories that are anticipated to be used are listed below.

- Alta Analytical Laboratories, Inc., El Dorado Hills, California;
- Lancaster Laboratories, Inc., Lancaster, Pennsylvania;

- Paragon Analytics, Inc., Fort Collins, Colorado;
- STL Burlington, Colchester, Vermont, and
- Particle Technology Labs, Ltd., Downers Grove, Illinois.

The specific analyses to be provided by these laboratories are identified in Section 6.3.2.1. Appendix A provides qualifications (including resumes) for these laboratories.

5.1.2.4 Quality Assurance Contractor

Environmental Data Services, Ltd. (EDS), Pittsburgh, Pennsylvania, will serve as the Quality Assurance Contractor (QAC) by providing data validation services as part of the IWP implementation. Ms. Diane Waldschmidt will serve as PM for EDS. Appendix A provides EDS's pertinent qualifications and Ms. Waldschmidt's resume.

The EDS PM will function in the same manner (within EDS) as the Lead Consultant (Section 5.1.2.1), and will also assist the FC and QAO in implementing the project's QA/QC program (Section 7).

5.1.2.5 Source Identification Contractor

The Source Identification Program will be managed by The Intelligence Group, LLC (TIG), Far Hills, New Jersey, and Mr. Dennis Farley will serve as PM. Appendix A provides TIG's corporate qualifications and Mr. Farley's resume.

For work efforts implemented within TIG, the TIG PM will serve in a role similar to the Lead Consultant PM (Section 5.1.2.1).

5.2 Quality Objectives and Criteria

5.2.1 Data Quality Objectives

DQOs are developed to ensure that the data collected will be of sufficient quantity and quality to serve their intended uses. This section describes the DQOs pertaining to type, quantity, and quality of data.

5.2.1.1 Levels of Data Quality

DQOs are based on the concept that different data uses require different levels of data quality. Data quality can be defined as the degree of uncertainty in the data with respect to precision, accuracy, representativeness, completeness, and comparability. The five general levels of data quality are as follows:

Screening (Level 1): This provides the lowest data quality but the most rapid results. It is used primarily for initial site characterization to locate areas for subsequent higher quality analysis, health and safety monitoring, and initial screening of alternatives (i.e., bench-scale tests). These include monitoring equipment data such as photoionization detector, flame ionization detector, pH, Dissolved Oxygen, Eh, conductivity, and temperature meters.

Field Analysis (Level 2): This provides rapid results and better quality than Level 1. Analyses include data generated in a mobile laboratory.

Engineering (Level 3): The data quality generated at this level is intermediate and is used for site characterization. These analyses may include mobile laboratory-generated data, some analytical laboratory methods (i.e., laboratory data used for screening that lack full QC documentation), and toxicity testing.

Confirmation (Level 4): This provides the highest level of data quality and is used for purposes of risk assessment, FS, remedial design, and cost analysis. These analyses require full Contract Laboratory Program (CLP) analytical data validation procedures in accordance with USEPA requirements.

Non-Standard (Level 5): This level of quality is similar to Level 4 data, except it refers to analyses following non-CLP protocols (e.g., SW-846 methods).

Chemical and radiochemical analyses will be performed using procedures designed to produce Level 5 data quality. Bulk density measurements will be made in the field while grain size and moisture content analyses will be performed by an off-site laboratory. Data quality levels for bulk density, grain size and moisture content will be Levels 1, 3 and 3 respectively.

5.2.1.2 Analyte Specific Data Quality Objectives

Analyte-specific DQOs or Sample Quantitation Limits (SQLs) for parameters proposed for analysis during the IWP are provided in Tables 5-1 through 5-10. These reporting limits will be used as target analyte-specific DQOs.

5.2.2 Data Quality Measurement Parameters

All data are potentially subject to some uncertainty and error as they are generated through sampling, analysis, and reporting. Control and recognition of errors is important in assessing data quality and preparing technical reports. The impact of data uncertainty and errors on the project can be reduced in two ways: 1) through QC measures and 2) through documentation of the quality or nature of data error or uncertainty for the data generated.

In order to evaluate whether the analytical data are consistent with the DQOs of each task, an assessment of the performance of five data quality measurement parameters is performed. These data quality measurement parameters include precision, accuracy, completeness, representativeness, and comparability, and are discussed in this section. Quantitative limits for acceptable precision, accuracy, and completeness are discussed below.

5.2.2.1 Precision

Precision is the measure of variability between individual sample measurements of the same property under prescribed similar conditions. The measurement of precision is made through the use of replicate samples taken at regular, specified intervals.

Replicate samples are collected in the field, homogenized before being split into two distinct samples (also known as field duplicates) or prepared during laboratory analysis (laboratory duplicates), and are expected to contain identical contaminant concentrations. Therefore, any variability in the reported analyses is attributable to variability introduced by sampling, handling, or analytical procedures. Analysis of field duplicate samples provides an estimate of overall sampling and analysis precision. Analysis of laboratory duplicates provides an estimate of analytical precision.

Frequency of collection of field duplicate samples is discussed in Section 6.7.1, and Tables 5-11 and 5-12. The precision of field replicate analyses (field duplicates) and laboratory replicate analyses is expressed as relative percent difference (RPD).

Field precision and inorganic analytical precision will be expressed as RPD for co-located and homogenized duplicate environmental sample results and laboratory duplicate analysis results, as described below:

$$RPD\,(\%) = \frac{|S - D|}{(S + D)/2} \; x\,100$$

Where:

S = First sample value (original); and
D = Second sample value (duplicate).

Organic analytical precision will be expressed as the RPD of the percent recoveries for the Matrix Spike (MS)/Matrix Spike Duplicate (MSD) samples as follows:

$$RPD\,(\%) = \frac{|R1 - R2|}{(R1 + R2)/2} \; x\,100$$

Where:

R1 = MS; and
R2 = MSD.

Laboratory acceptance limits for precision are stated in Section 6.6.1. The control limits for precision to be used in data validation are stated in Section 8.

5.2.2.2 Accuracy

Accuracy is a measure of the bias in a system and can be defined as the degree of agreement between a measurement and an accepted reference or true value. The exact bias of a system is never known since the true values are not accessible. However, inferences can be drawn from an evaluation of various analyses. The accuracy or bias of a laboratory analysis is evaluated by analyzing standards of known concentration both before and during sample analysis. Bias is also evaluated by spiking a sample (MS) with a known quantity of a chemical and measuring its actual, versus expected, recovery in analysis. Similarly, any bias introduced by laboratory contaminants is detected during blank analysis. Analytical quality control samples, which will be used to control analytical accuracy, are discussed in Section 7. Analytical accuracy is also measured through procedures detailed in the SOPs of most analytical methods.

Accuracy will be expressed as percent recovery (%R) for spiked samples (surrogate spikes, laboratory control samples [LCS]) as follows:

$$\%R = \frac{M}{A} \, x \, 100$$

Where:

M = measured concentration in spiked sample; and
A = actual spike concentration in sample.

In addition, the MS/MSD sample results will be used to calculate the %R in accordance with the following formula:

$$\%R = \frac{(T - X)}{A} \, x \, 100$$

Where:

T = total concentration found in spiked sample;

X = original concentration in sample prior to spiking; and

A = actual spike concentration added to sample.

Laboratory acceptance limits for accuracy are discussed in Section 6.6.1. The control limits for accuracy to be used in data validation are discussed in Section 8.

Accuracy in regards to sampling procedures is also evaluated through the use of blanks. For example, field blanks or equipment rinsate blanks may demonstrate bias introduced by contaminated sampling equipment, sample containers, or sample handling. Section 6.7.1 presents a discussion of quality control samples collected in the field to be used to evaluate the accuracy of the data.

5.2.2.3 Completeness

Field completeness is a measure of the number of samples planned to be collected compared to the number of samples that are received in acceptable condition by the laboratory(ies). Analytical completeness is a measure of the number of overall accepted analytical results (including estimated values) compared to the total number of analytical results requested on samples submitted for analysis. Both the overall field completeness and overall analytical completeness goals are 90% for the IWP.

Following validation of the data packages in accordance with the provisions of Section 8, assessment of the data with respect to fulfillment of QA objectives will be accomplished by the joint efforts of the QAO, QAC, and the FC. This assessment will consider sample collection, sample handling, field data, blank values, field duplicate values, and additional data flags or qualifiers.

The overall field completeness will be calculated by the ratio of the number of samples received in acceptable condition by the laboratories to the number of samples planned to be collected as specified in this document. The equation for overall field completeness is:

$$\%\ Field\ Completeness = \frac{Number\ of\ Samples\ Received\ by\ Laboratories}{Total\ Number\ of\ Samples\ Planned\ to\ be\ Collected}\ x\ 100$$

It is important to note that the total number of samples planned to be collected (i.e., the denominator) could be affected based upon Tierra's pre-mobilization meeting with USEPA and USACE. The purpose of the meeting is to verify that the number, location, and depth of cores proposed for collection within the ports and navigation channels are appropriate given current conditions and recent dredging activity.

The overall analytical completeness will be calculated by the ratio of total valid analytical data results (including estimated values) to the total number of analytical results requested on samples submitted for analysis. The equation for the overall analytical completeness is:

$$\%\ Analytical\ Completeness = \frac{Total\ Valid\ \ Analytical\ Data}{Analytical\ Data\ Obtained}\ x\ 100$$

Analytical and field completeness will be determined and compared to their respective goals as stated above. If the goals are not met, the QAC and the QAO will decide if the data are sufficient for site characterization and other data uses. If it is judged that the data are inadequate, additional field samples may be collected and analyzed to accomplish the study goals. Decisions to repeat sample collection and analysis may be made by the FC in consultation with the QAC and QAO based on the extent of the deficiencies and their importance in the overall context of the IWP.

5.2.2.4 Representativeness

Representativeness is the degree to which a set of data may accurately represents the characteristics of a population, parameter conditions at a sample point, or an environmental condition. Representativeness is evaluated by collecting QC samples and performing sampling and sample handling/processing in compliance with appropriate procedures. Field SOPs, or detailed descriptions of sample collecting, handling and processing procedures, are found in Appendix B.

5.2.2.5 Comparability

Comparability expresses the confidence with which one set of data can be compared to another to measure the same property. Data can be compared to the degree that their accuracy, precision, and representativeness are known and documented. Data are comparable if QC measures such as collection techniques, measurement procedures, analytical methods, and reporting units are equivalent for the samples within a sample set. Data subject to established QA/QC measures are deemed more reliable and, therefore, more comparable, than data generated without such measures.

5.2.3 Analytical Accuracy and Precision Limits

The laboratory limits for accuracy (as measured by the percent recoveries for surrogate spike compounds, MS/MSD, and LCS analyses) and precision (as measured by RPD between laboratory duplicate recovery results and MS/MSD recovery results) will be either the laboratory control limits based on historical data calculated as specified in the analytical methods or the limits specified in Section 6.6.1 of this IWP.

To the extent possible, the analytical method QA/QC limits for accuracy and precision specified in this IWP are based on those set forth in "Test Methods for Evaluating Solid Wastes, SW-846" (SW-846). For semivolatile base neutral/acid fraction organics, volatile organics, Aroclor PCBs, pesticides, metals including mercury, cyanide, and chlorinated herbicides the accuracy and precision limits are those specified in the SW-846 analytical methods. The accuracy and precision limits for congener PCB, PCDD/PCDF, TEPH, radiochemistry, and Total Organic Carbon (TOC) are specified in Section 6.6.1 of this IWP, as SW-846 does not contain analytical methodologies or accuracy and precision limits for these analytes.

If the limits specified in Section 6.6.1 of this document are not met, the laboratory will follow the corrective actions specified in the analytical method. The accuracy and precision limits used for evaluating the quality and usability of the data are specified in Section 8.

5.3 Special Training/Certification

Personnel engaged in sampling activities are required to have proper Health and Safety Training as required by the Occupational Safety & Health Administration (OSHA) Regulation 29 CFR 1910.120 (HAZWOPER). Field employees will also receive a minimum of three days of actual field experience under the direct supervision of a trained, experienced supervisor. Personnel who completed their initial HAZWOPER training more than 12 months prior to the start of the project will have completed an 8-hour refresher course within the past 12 months. The contractor's Site Supervisor will have completed an additional 8 hours of supervisory training and have a current first-aid/cardiopulmonary resuscitation certificate. In addition, personnel who are potentially exposed to Newark Bay COPCs will participate in a medical surveillance program as defined by OSHA at 29 CFR 1910.120(f).

Field personnel collecting samples and/or operating field instrumentation will be trained in the required procedures provided in Appendix B of this IWP (Field Standard Operating Procedures).

Certificates or documentation representing completion of specialized training shall be maintained by the sampling contractor's PM within the personnel files. Refer to RIWP Volume 3 (Tierra, 2005) for additional information relative to this topic.

Laboratories performing analytical work in support of this project are required to have each analyst demonstrate an ability to generate an acceptable initial demonstration of capability (IDC), along with acceptable results according to method recommendations and stated project data quality objectives.

Documentation representing successful completion of individual analyst IDC as described above will be maintained by the laboratory's quality assurance manager or their designee.

5.4 Documents and Records

5.4.1 Document Control

In order to provide appropriate project personnel with the most current and updated version of the RIWP, individuals identified on the distribution list will receive updates or subsequent versions with instructions on what to do with previous documents in their possession (e.g., consider new information an update, dispose of superceded version). Use of the form of header shown on this IWP (which contains a revision number and date) will ensure the consistency and currency of document distribution. This same control procedure will be used for other reports generated as part of the RIWP Program.

5.4.2 Project Files

Project documentation will be placed in a central project file (known as the Newark Bay Central Project File). This file will be maintained and controlled by the Lead Consultant, and will consist of the following components:

1. Agreements (filed chronologically);
2. Correspondence (filed chronologically);
3. Memos (filed chronologically); and
4. Notes and data (filed by topic).

Reports (including QA reports) will be filed with correspondence. Analytical laboratory documentation (when received) and field data will be filed with notes and data.

Duplicate copies of pertinent field-related correspondence/documentation will be maintained at the field office during field operations. Once such field operations have been completed, this documentation will be transferred to the Newark Bay Central Project File.

5.4.3 Reporting Format

5.4.3.1 Sample Collection Reports

During implementation of the Phase I SI and Source Identification Programs, logbooks will be maintained in the field according to SOP 1 – Field Documentation and Section 6.4.4.6. Field crews will document, at a minimum, activities performed; type and identification number of samples collected; equipment and sampling method used; meteorological conditions; and difficulties or unusual observations observed in the field. QC samples collected will also be recorded in the logbook, including type (e.g., field blank, duplicate, etc.) and preservation methods used.

Chain of custody records will be completed and included with the samples submitted for laboratory analysis. Further information on chain of custody requirements are provided in Section 6.5.2.

5.4.3.2 Laboratory Reports

The laboratory will prepare and retain full analytical and QC documentation. The laboratory will report the data as a group of 20 environmental samples (including blanks, duplicates, and performance evaluation [PE] samples as appropriate) or fewer, along with QC supporting data. These groupings of samples (Sample Delivery Groups [SDGs]) will be assigned by the field sample collection and processing team.

For each analysis type other than the high resolution analyses, the laboratory will, at a minimum, provide the hard copy information listed below in each analytical data package submitted using CLP-equivalent forms. These forms shall contain information contained on the CLP forms that is pertinent to the analytical method requirements, including but not limited to the following:

Case Narrative; cover sheet listing the samples included in the report and narrative comments describing problems encountered in analysis, identification of analyses not meeting QC criteria (including holding times), listing of samples that need corrective action and what corrective action was taken (e.g., reanalysis), and copies of correspondence related to the samples in the package, including chain of custody documents. Case narratives submitted with each data package will include a summary of the analytical methods performed. These summaries will describe, at a minimum, the details of any optional processes allowed within the USEPA or other standardized procedures that were applied to IWP samples within each delivery group.

- Analytical results for QC sample spikes, sample duplicates, initial calibration, and continuing calibration verifications of standards and blanks, standard procedural blanks, and LCSs.

- Tabulated results of compounds identified and quantified, dilution factors, and the reporting limits for all analytes. Organic analytes detected below the SQL, but above the Method Detection Limit (MDL) will be reported with a "G" flag, and organic analytes detected below the SQL and MDL will be reported as non-detects at the SQL. Inorganic analytes detected below the SQL but above the Instrument Detection Limit (IDL) will be reported with a "B" flag, and inorganic analytes detected below the SQL and IDL will be reported as non-detects at the IDL.

- Summary reports for initial and continuing calibrations listing relative response factors and percent relative standard deviations for organics, and percent recoveries and true values for metals; MS/MSD percent recoveries and RPDs for organics and MS recoveries and spike amounts for metals; surrogate spike percent recoveries and spike amounts (if applicable); laboratory blank results, and a method blank summary listing method blanks and associated samples; and LCS results (if applicable).

- Raw data system printouts (or legible photocopies) and chromatograms (identifying sample identification, date of reported analysis, parameters analyzed) for samples, initial calibration, calibration verifications, method blanks, any reported sample dilutions, sample duplicates, spikes, and control samples; sample spiking levels; preparation/extraction logs and run logs.

For all high resolution analyses (PCDD/PCDFs and PCB congeners and homologues), the data packages will include, at a minimum, the following:

- Case Narrative;
- Chain of custody Form;
- Copies of Correspondences Related to Samples in Package;
- Analysis Data Sheet (Form 1a);
- Confirmation Analysis Data Sheet (Form 1b), if applicable;
- Cleanup Standard Recoveries (Form 2);
- Initial Calibration Relative Responses (Form 3a);
- Initial Calibration Response Factors (Form 3b);
- Initial Calibration Ion Abundance Ratios (Forms 3c and 3d);
- Calibration Verification (Forms 4a and 4b);
- Retention Time Windows (Form 5);
- Sample Relative Retention Times (Form 6a and 6b);
- Initial Precision and Recovery (Forms 7a and 7b);
- Ongoing Precision and Recovery (Forms 8a and 8b);
- MS/MSD Results and Spiking Level Summary;
- Selected Ion Current Profiles (SICPs) for the Initial Calibration (5 concentrations run one time);
- Mass Spectrometer resolutions demonstration SICPs for each analysis shift;
- Gas Chromatograph resolution demonstration SICPs for each analysis shift;
- SICPs for one calibration standard for each analysis shift; and
- SICPs for each sample and blank run.

The gas chromatogram/mass spectrometer displays for the PCDD/PCDF and PCB congeners and homologues analyses will include the standard and sample SICP chromatograms as specified in the analytical method with the date and time of analysis, the file name, sample number, and instrument ID number. The SICP mass chromatograms will also have the quantitation ion and confirmation ion displayed, integrated area, and peak height listed for peaks 2.5 times above background. In addition, peaks will show retention time at the maximum height.

Laboratory data qualifiers will be provided by the analytical laboratory. These qualifiers will be consistent in definition and application with those currently residing in the comparison database. The standardized laboratory data qualifiers to be used during laboratory data reporting are provided in Table 5-13. Standardized laboratory data qualifiers allow for more accurate data comparisons when evaluating multiple data sets.

Electronic deliverables are required of the laboratory. These deliverables will be submitted along with the hardcopy data package reports described earlier, and will be in Microsoft Excel spreadsheet format. Table 5-14 is an example of the format to be provided in the laboratory electronic deliverable.

5.4.4 Complete Data Files

Upon completion of the data validation process, field sample collection chain of custodies, laboratory data packages, completed assessment checklists, telephone record log(s), data summary sheets, and data assessment narratives shall be stored in the Newark Bay Central Project File (Section 5.4.2).

5.4.5 Additional Reports

In addition to reports associated with sampling activities (e.g., logbooks, instrument printouts), audits will be performed at various times during the IWP, and reports documenting their findings will be generated. Specifics on these audits and reports are provided in Section 7 of this IWP.

6. Generation and Acquisition of Phase I SI Data

This section provides the details necessary to implement the Phase I SI Program. In addition, the QA program procedures that will be put into place to help ensure that data of acceptable quality will be obtained during the process are presented in this section.

The primary objective of the Phase I SI is to fulfill RI Goal 1, which is to "determine the horizontal and vertical distribution and concentration of PCDDs, PCDFs, PCBs, PAHs, pesticides and metals for sediments in the Newark Bay Study Area" (SOW Section A.1). Additionally, the Phase I SI Program will provide initial insight into addressing RI Goal 2 (Risk Assessment) and RI Goal 3 (Source Identification).

As indicated in Section 4.1, this program is to be conducted in two phases. The Phase I SI Program will collect sufficient data to design a subsequent sediment collection program (Phase II), and includes a BAZ investigation, bathymetric surveying, and sediment collection tasks. Each of the Phase I SI tasks is described further in the following sections.

6.1 BAZ Investigation

6.1.1 Rationale

Surface sediments play an important role as potential habitats for aquatic organisms, particularly invertebrates. The depth of the BAZ—that zone in which organisms exist within the sediments—is often assumed to be approximately 0.5 ft in aquatic systems, but the actual depth may vary.

The objective of this BAZ investigation is to determine the depth of BAZ, on average, in Newark Bay. Results of the BAZ investigation will be used to adjust (if necessary) the current assumed depth of 0.5 ft for both modeling and risk assessment purposes.

6.1.2 Scope

The BAZ investigation will be conducted at 14 locations, each placed immediately adjacent to a proposed Phase I core (Figure 6-1). The 14 locations were selected to provide reasonable spatial coverage within the Bay. Particular emphasis was given to the Sub-tidal Flats (six BAZ locations) and Inter-tidal Areas (five BAZ locations) since these areas are not regularly disturbed by dredging, and will likely provide the highest potential for ecological exposure to contaminants. Three BAZ locations were placed in the Navigational Channels (one location in the Northern Navigational Channels and two locations in the Southern Navigational Channels) to assess benthic invertebrate activity in disturbed areas, as well as to gain insight into the recolonization of previously dredged areas.

At each BAZ location, the following tasks will be performed:

- Two SPI deployments with multiple images will be collected using an SPI camera that is submerged into the sediments up to 18 inches in depth (or to refusal); and
- Three surface sediment grab samples will be collected in the area surrounding the SPI imaging location for in-field visual examination of texture, color, and general benthic invertebrate activity.

Following collection, the SPI images will be visually evaluated to determine the depth to which benthic organisms are penetrating into and bioturbating the sediments. In addition, it is anticipated that the images will confirm the location of the redox change, as this point is usually visible as a clear change from black (oxidized) to grey (reduced) colored sediments. The grab samples that are collected and inspected will be used to provide additional information on the sediment's characteristics, and will help in corroborating that which can be interpreted from the SPI images.

In addition to the SPI images and field data that are collected under this program, previous SPI images that were collected by NOAA (1995) in Newark Bay will be used to supplement and expand the dataset. These historical images will help characterize the variability of metrics (both spatially and temporally) that can be used to quantify the BAZ.

6.2 Bathymetric Survey

6.2.1 Rationale

For purposes of the Phase I SI Program, bathymetric survey data for Newark Bay are important for verifying the identified geomorphic areas, and assisting the field crew in locating various cores. Available NOAA bathymetric charts of Newark Bay reveal the complex bathymetry adjacent to the navigational channels and around shoreline structures and bridge crossings (Figure 3-3). These charts provide an indication of water depths throughout Newark Bay, including the Sub-tidal Flats outside of the channel; however, they present a combination of data from various surveys over the period of 1982 through 2002. These data sets provide only limited information in some areas, and data were not readily obtainable in electronic format. Fairly extensive and recent bathymetric survey data are available for the Navigation Channels south of Port Newark from the USACE. More limited information is available for the Channels north of Newark Bay.

The objective of the bathymetric survey is to acquire bathymetric data in such a manner to provide an accurate representation of the depth and morphology of the Bay relative to known horizontal and vertical datums. The survey will be conducted in such a manner that the acquired data are accurate and repeatable, with a calculable error for horizontal and vertical coordinates. For the purposes of this project, vertical data will be corrected to North American Vertical Datum of 1988 (NAVD88), and horizontal coordinates will be referenced to the New Jersey State Plane Coordinate System, North American Datum of 1983 (NAD 83).

6.2.2 Scope

The bathymetric survey will be conducted along tracklines distributed over nearly the entire Phase I SI Study Area. The planned survey tracklines extending across the Bay will be spaced at approximately 0.25-mile intervals oriented perpendicular to the Bay. More closely-spaced, shorter tracklines are positioned to provide detailed representation of depths around shoreline structures, bridge crossings, and sharp breaks in the Navigational Channel banks. Tie-lines, perpendicular to the primary survey lines, will be run as appropriate to provide a quality control check of the data acquisition and survey procedures.

To aid in obtaining and interpreting the bathymetric data, one tide gage will be installed during the mobilization process at a location yet to be determined. Information collected from this tide gage will also be useful in the sediment collection process. It is anticipated that tide gage data will be used in conjunction with the available tide gage data being collected by NOAA/National Ocean Service at Bayonne Bridge.

6.3 Sediment Collection

6.3.1 Rationale

A prime component of the Phase I SI Program involves the collection and analysis of sediment from the Phase I SI Study Area (Figure 1-2). The sampling program has been designed to represent existing conditions, since an inappropriate design could diminish the representativeness (and therefore usefulness) of the data collected.

To meet this objective, the Phase I SI Study Area was stratified into various regions according to the geomorphic areas described in Section 3. This stratification process will assist in reducing variability of the resulting data, and will be helpful in increasing the power of subsequent data analyses. As described in Section 3, a total of eight unique Newark Bay geomorphic areas were identified as part of the preliminary CSM. For purposes of this IWP, seven of these eight units will be included as part of the Phase I SI Program (Section 4.2).

The Phase I SI Program is based on a deterministic sampling design, combining aspects of both judgmental and random techniques. These techniques were used to select the sampling locations within each geomorphic area based on the information available.

Judgmental sampling is the biased selection of sampling locations based on historical information, visual inspection, and professional judgment. According to USEPA, "The judgmental approach is best used as a screening investigation to be followed with a statistical approach when determining extent of contamination or action alternatives" (USEPA, 1995). For purposes of designing the Phase I SI Program, the historical data were graphed and reviewed to assess the sample density and coverage (see RIWP Volume 1 [Tierra, 2004]). These graphs assisted in identifying areas that were void of data.

Using purely judgmental techniques, however, may not allow for quantification of decision errors related to the number of sample locations (as is done in the seven-step DQO process discussed in Section 4.1), and the sampling is only as good as the CSM used to define the target population, which, at this time is not fully developed. To account for this, and to improve data representativeness, randomization is necessary to make valid probability or confidence statements about the sampling results. To provide the randomization, systematic sampling within geomorphic areas was also used in the selection of Phase I SI sampling locations, especially for relatively larger, contiguous areas within geomorphic areas (i.e., non-fragmented areas where multiple locations could be assigned). Systematic sampling involves subdividing the targeted area by using a grid system and collecting sediment from the nodes of the grid so that the distance between sampling locations is similar. The number of locations desired within a given area will determine the grid spacing. The orientation of the grid is determined using an initial random point and aligning the grid with the longest axis of the targeted area.

As presented in the AOC, the depth of sediment sampling should seek to identify the 1940 horizon. As such, the historical deposition rates (determined either from radiodating or changes in bathymetry over time) were used to estimate the approximate depth of the 1940 horizon in each geomorphic area, as well as to determine sample segmentation. If the 1940 horizon was determined to no longer exist in a geomorphic area (i.e., removed through dredging activities), the program targeted a depth of sediment based on a more limited data use objective, together with any relevant historical information (i.e., depth of most recent dredging program). Therefore, the sampling depth and associated segmentation strategy were determined using judgmental techniques.

Specifics regarding the planned scope of work within the seven geomophic areas are provided below.

6.3.2 Scope

For the Phase I SI Program, sediment cores will be collected from the following seven geomorphic areas:

- Southern Navigation Channels (South of Port Newark);
- Northern Navigation Channels (North of Port Newark);
- Port Channels;
- Transitional Slopes;
- Sub-tidal Flats;
- Inter-tidal Areas; and
- Industrial Waterfront Areas.

As presented in Section 3.1.2, these areas represent approximately 99% of the Phase I SI Study Area.

As described further herein, a total of 69 coring locations are proposed for this initial phase of sampling (Figure 6-1). At each location, a primary core will be collected for purposes of chemical analyses. The exact number of samples obtained from the core will depend on the length of cores retrieved, as further discussed below. At locations where radiochemical data will be collected (i.e., total of 51), a second, short core will be collected to obtain adequate sample volume for the BAZ sample. A BAZ sample depth of 0-0.5 ft was used for purposes of designing this Phase I SI Program; however, this depth may change based on the results of the BAZ investigation (Section 6.1). Additionally, a surface grab sample will be collected at these same 51 locations for ^{7}Be analysis. At the 18 locations where radiochemical analyses are not collected (i.e., Southern Navigation Channels and Port Channels), the appropriate sample volume can be obtained from the primary core.

6.3.2.1 Analytical Testing

Samples collected as part of the Phase I SI Program will be analyzed for the following chemical groups:

- Pesticides and Aroclors
- Semivolatile Organics
- Volatile Organics
- Metals
- Cyanide
- Organotins
- PCB Congeners and Homologues
- Chlorinated Herbicides
- Dioxin/Furan Isomers
- Total Extractable Petroleum Hydrocarbons

In addition, grain size will be analyzed for a maximum of three sample segments within each core. For cores less than 4 ft, grain size will be determined at the top and bottom segment. For cores greater than 4 ft, grain size will be determined at the top, middle, and bottom segment. For each core collected, the field crew will also obtain pertinent information to calculate a bulk density for the entire core length.

During this investigation, 209 individual PCB congeners, as well as 17 dioxin and furan isomers, will be characterized. Tables 5-4, 5-5, and 5-7 list specific PCB congeners and dioxin/furan isomers to be evaluated during implementation of this IWP. Details regarding the specific extraction and analytical methods to be conducted are described in Section 6.6.

6.3.2.2 Radiochemistry Testing

For purposes of radiochemistry analyses, ^{210}Pb, ^{7}Be, and ^{137}Cs activity will be measured at select locations during the sampling program. These analyses will assist in dating the sediment for use in estimating the depth of the 1940 horizon, quantifying sediment deposition rates, and may verify recent deposition. The following provides a brief explanation of each analysis.

^{210}Pb Radiodating

^{210}Pb radiodating is based on two major assumptions. First, it is assumed that atmospheric contributions of ^{210}Pb to sediments are constant over time and, therefore, a decrease in the concentration of ^{210}Pb related to atmospheric deposition will occur in buried sediments as a result of radioactive decay (Appleby and Oldfield, 1978). To obtain the atmospheric concentration, a correction is made to the ^{210}Pb concentration for other natural contributions (background) from radioactive decay from elements for which it is a daughter product (Appleby and Oldfield, 1978). Thus, the unsupported ^{210}Pb concentration in sediment should decrease exponentially as a function of time, since radioactive decay follows first order kinetics (the rate of decay is solely a function of the concentration of the ^{210}Pb present). The rate constant for ^{210}Pb decay is 3.11×10^{-2}/year.

Second, it is assumed that the rate of sediment deposition at a given location is constant over time. Therefore, the sediment depth is assumed to be a linear function of time of deposition, knowing the decay constant. A sedimentation rate can be calculated from the slope of the regression line obtained by plotting the ^{210}Pb concentration as a function of sediment depth. A plot of the logarithm of the activity as a function of time should theoretically be a straight line with the slope of the line directly related to the rate of radioactive decay.

It is important to understand that this second assumption of constant sediment deposition must be assessed within the context of the study's period of interest. Sediment transport and deposition are, by nature, episodic; however, the longer the periods over which the average rate of deposition is estimated, the less the individual events influence the results. Furthermore, the linearity of the depth/decay curve can be an indication of accuracy of this constant sediment deposition assumption. For example, a high correlation (i.e., r^2) would indicate relatively uniform deposition; an inflection point may be indicative of changing sedimentation rate with time (i.e., in watershed management practices); and a discontinuity in the slope may indicate a large episodic erosion or deposition event.

It is also important to understand that in areas where slower deposition rates are observed, episodic events and/or general surface processes (e.g., bioturbation) could affect dating results moreso than in areas of higher deposition.

^{7}Be Radiodating

^{7}Be is a natural fallout nuclide with a half-life of 53 days. This radionuclide produced by cosmic rays is present in both suspended matter and near-surface sediments if there has been recent deposition (Holmes, 1998). Because of the short half-life, ^{7}Be is not expected to be detectable at depth. The ^{7}Be activity is reduced to 9% of its original value after 6 months, and is reduced to less than 1% after 1 year. The measurement of ^{7}Be activity in sediment cores will be used to determine whether there has been recent sedimentation and whether the near-surface portion of the core is intact after the sampling process.

^{137}Cs Radiodating

The ^{137}Cs radiodating technique that will be utilized for the Phase I SI is based on the premise that ^{137}Cs was first associated with sediments deposited in 1954 as a result of fallout from atmospheric testing of large nuclear weapons beginning that year. The sediment horizon associated with this date is interpreted as those sediments where ^{137}Cs is first detectable.

Additionally, in cores with continuous and relatively rapid sediment accumulation, the maximum levels of ^{137}Cs can be associated with the years of peak fallout delivery of 1963 to 1964 (Robbins and Edgington, 1976). However, the analytical uncertainty associated with identifying the point of maximum activity is greater than that for identifying the point of first measurable activity, making it difficult to assign the 1963 horizon to a specified depth.

6.3.2.3 Sediment Collection By Geomorphic Area

The scope and associated rationale for each geomorphic area is discussed in greater detail below, including the vertical segmentation scheme (for both chemistry and radiochemistry, where appropriate). Figure 6-1 illustrates the spatial layout of the sampling locations discussed.

A summary of the estimated number of chemical samples (including QA/QC) per geomorphic area is provided in Table 6-1, while Table 6-2 provides a similar estimate for samples submitted for radiochemistry.

Southern Navigation Channels (South of Port Newark)

A series of recent dredging projects within Newark Bay have greatly impacted the nature and extent of sediments accumulated in the southern two-thirds of the Navigation Channels, including portions of Arthur Kill and Kill van Kull. As noted in Figure 2-1, the entire channel network south of Port Newark has been dredged since 2001. This dredging is scheduled to continue through the remainder of the decade, and is to include routine maintenance and additional deepening/widening (Figure 2-2).

The extensive dredging activities affect not only the amount of sediment accumulated, but also the time period represented by a vertical core profile and the length of time that the present sediment will be available to the Newark Bay ecosystem. Reported deposition rates in the South and Middle Reaches of the channel range from 0.8 to 4.7 in/yr (USACE, 1986). Average deposition rates in the Bay reaches of the Arthur Kill range from 11.7 in/yr in the North of Shooters Island Reach, to 5.4 in/yr in the South of Shooters Island Reach. Much of the Kill van Kull waterway has lower deposition rates, on the order of 0.1 in/yr (USACE, 1986). Based on a compilation of USACE records for the period 1952 to 1976, Suszkowski (1978) found significantly lower rates for the South Reach (0.1 in/yr).

Sampling for Chemical Analyses

To characterize the sediments in the Southern Navigation Channels during the Phase I SI Program, a total of 12 coring locations were identified south of Port Newark (Figure 6-1). Prior to initiating core collection activities, Tierra will meet with the USACE to decide if select core locations need to change due to on-going dredging activities. The 12 sampling locations presented herein were selected using a systematic random approach at approximately equal distances along the channel.

Recent deposition in these areas may make the observation of concentration differences among cores more difficult. This is due to both the lack of current point sources in the South Channel (leading to a greater anticipated degree of homogeneity in recently deposited sediment), and the generally lower concentrations associated with more recent deposition.

In addition, it is expected that minimal variability will be observed in the vertical chemical profiles due to the contemporaneous nature of the sediment deposition (unless there are historical dredging residuals present at the bottom of the core). Given these factors affecting both net accumulation and anticipated lack of significant variability in chemical concentrations within individual cores, the informational value of the vertical segments is expected to be relatively low. Therefore, the vertical segmentation scheme for chemical analyses within this geomorphic area will be limited to a maximum of three samples per core. The target penetration is 3 ft, and the segmentation scheme is shown below.

Chemical Segmentation Scheme
Southern Navigation Channels (South of Port Newark)

Penetration	Segment 1	Segment 2	Segment 3
< 1.0 ft	0 – 0.5 ft (BAZ)	NA	NA
1.0 – 2.0 ft	0 – 0.5 ft (BAZ)	0.5 ft – bottom	NA
2.0 – 3.0 ft	0 – 0.5 ft (BAZ)	0.5 – 1.5 ft	1.5 – 3.0 ft

NA = Not Applicable

A more detailed breakdown of the coring locations (including coordinates) and the associated vertical segmentation scheme are provided in Table 6-3.

Sampling for Radiochemical Analyses

As a result of both recurrent and recent dredging activity, "historical" sediments are not likely to exist in the cores obtained in the Southern Navigation Channels (South of Port Newark). Therefore, there will be no radiochemical analyses at the 12 sediment core locations in this particular geomorphic area.

<u>Northern Navigation Channels (North of Port Newark)</u>

For the navigation channels in the northern portion of the Bay, where dredging is reported not to have occurred within the last 15 years, significantly thicker sediment accumulations are likely to be present in comparison to the more recently dredged areas to the south. Dredging in the North Reach, Kearny Point Reach, and Droyers Point Reach last occurred in 1989, 1983, and 1986, respectively (Table 2-2).

The USACE has reported deposition rates as high as 7 in/yr (USACE, 2004b) for the North Reach. Suszkowski (1978) reported sedimentation rates of 2.2, 5.8, and 1.6 in/yr in the North Newark Bay Channel, Kearny Point Reach, and Droyers Point Reach, respectively. In the 15 years (18 years for Droyers Point Reach and 21 years for Kearny Point Reach) since dredging last occurred, these rates could have resulted in net sediment accumulation on the order of 8 to 10 ft.

Sampling for Chemical Analyses

For this geomorphic area, six coring locations are proposed for the Phase I SI Program (Figure 6-1), including four in the Navigation Channel and two in Droyers Point Reach (associated with the Hackensack River). The locations are spaced systematically along the channels at approximately equal intervals with a random initial location.

As noted earlier, this area could have sediment accumulations of as much as 10 ft. In these deeper accumulations, it is expected that the vertical profile will reflect a degree of historical chemistry changes. Therefore, the vertical segmentation scheme for cores collected in this geomorphic area was chosen to provide both a consistent segmentation of near-surface sediments (the upper 3.5 ft), and variable length segments from deeper portions of the core based on total sediment depth. The target penetration for the Northern Navigation Channels (North of Port Newark) is 11 ft; the segmentation scheme for obtaining samples for chemical analyses is shown in the table below.

Chemical Segmentation Scheme
Northern Navigation Channels (North of Port Newark)

Penetration	Segment 1	Segment 2	Segment 3	Remaining Segments
< 2.25 ft	0 – 0.5 ft (BAZ)	0.5 ft – bottom	NA	NA
2.25 - 4.0 ft	0 – 0.5 ft (BAZ)	0.5 – 1.5 ft	1.5 ft - bottom	NA
4.0 - 6.0 ft	0 – 0.5 ft (BAZ)	0.5 – 1.5 ft	1.5 – 3.5 ft	3.5 ft to bottom
6.0 - 8.5 ft	0 – 0.5 ft (BAZ)	0.5 – 1.5 ft	1.5 – 3.5 ft	>3.5 ft - split in half
8.5 - 11.0 ft	0 – 0.5 ft (BAZ)	0.5 – 1.5 ft	1.5 – 3.5 ft	>3.5 ft - split in thirds

NA = Not Applicable

See Table 6-3 for additional information regarding coring locations and the associated vertical segmentation scheme.

Sampling for Radiochemical Analysis

In the northern portion of the Navigation Channel, there are no recorded large-scale dredging activities since 1989, allowing for potentially significant accumulation of sediment. Due to the dredging that occurred prior and up to 1989, any ^{137}Cs that may have deposited in previous decades is no longer present. Sediment dating in this geomorphic area will therefore rely only on ^{210}Pb analysis; however, there are some limitations with this approach as well.

It is recognized that the 15 years (18 years for Droyers Point) since dredging last occurred corresponds to less time than the 22.3 year half-life of ^{210}Pb. This limits the range of ^{210}Pb activity upon which the exponential decay slope used to compute deposition rates can be based. Another consideration is that the ^{210}Pb method assumes a uniform deposition rate over time. In this geomorphic area, changes in deposition rate may have occurred as the Navigation Channel has likely accumulated a significant amount of sediment. Finally, the ^{210}Pb method requires the establishment of a supported (background) level of ^{210}Pb activity in sediments not related to atmospheric contributions. Usually this is estimated based on the deepest sample(s) from a core, which represents a deposition period several half-lives ago. Since the 1989 dredging activities confound this assessment, the supported ^{210}Pb concentration will have to be estimated from cores taken in other geomorphic areas, such as deeper cores taken in the Sub-tidal Flats or Transitional Slopes. Given that this is a measure of natural background, the relatively close proximity of these other cores within the Phase I SI Study Area should not cause significant error in this analysis.

Vertical segmentation for ^{210}Pb analyses of the Northern Channel cores will include three near-surface samples (0 - 2 inch, 2 - 4 inch, and 4 - 6 inch depths), and six additional 2-inch segments taken at approximately the 1/6th, 2/6th, 3/6th,… depth intervals within the core. For cores less than 4 ft in length, the vertical segmentation scheme for the 3.5 ft Sub-tidal Flats core will be used. For example, if the core length is 54 inches, 2-inch segments will be taken around the 1, 3, 5, 9, 18, 27, 36, 45, and 53 inch depths. In addition to ^{210}Pb, surface sediments collected from this geomorphic area will be analyzed for ^{7}Be.

Table 6-4 provides additional information regarding the specific segmentation scheme associated with the radiochemical analyses.

<u>Port Channels</u>

There are three Port Channels present in the Phase I SI Study Area: Port Newark, Elizabeth, and South Elizabeth. As with the Southern Navigation Channels (South of Port Newark), these areas have an extensive history of dredging, and are actually dredged more frequently than the main channel. Port Newark Channel was last dredged in 2002, while the Elizabeth Channel and South Elizabeth Channel were dredged in 2004 (Figure 2-1). In addition, South Elizabeth Channel and Elizabeth Channel are scheduled for deepening to 50 ft in 2009 and 2011, respectively (Figure 2-2).

As with recently dredged sections of the Bay channel, these removal activities affect the amount of sediment accumulated, the time period represented by a vertical core profile, and the length of time that the sediment will be available to the local ecosystem. Reported average deposition rates for inshore portions of Elizabeth Channel, South Elizabeth Channel, and Port Newark Channel are 4.9, 1.7, and 4.7 in/year, respectively (USACE, 1986). Suszkowski (1978) reported sedimentation rates of 0.5 and 5.4 in/yr for Elizabeth and Port Newark Channels, respectively.

Sampling for Chemical Analyses

A total of six core locations were selected to characterize the sediments within the inshore sections of the Port Channels; with two core locations equally spaced along the length of each Port Channel (Figure 6-1). Two additional cores (cores 036 and 049) will also be collected at the western ends of the Port Newark and Elizabeth Channels to assess potential localized sources. Historical sediment data indicates higher concentrations of PCBs and PAHs in Port Channel sediments than in the main Bay, possibly due to the existence of several tributaries that drain into the Port Channels. Although the two cores are located within the respective Ports, they are considered to be associated with the Industrial Waterfront Area, and will be further discussed later in this section. As with the Southern Navigational Channels, Tierra will meet with the USACE to decide if select core locations should be altered.

While concentration differences among cores may exist, there is likely minimal variability in the vertical profile within individual cores due to the contemporaneous nature of the sediment deposition. A possible exception may exist where historical dredging residuals may be present at the bottom of the core. Given the factors affecting both the limited net accumulation and anticipated lack of significant variability in chemical concentrations within individual cores, the expected informational value of vertical segments is expected to be relatively low; therefore, the vertical segmentation will be limited to a maximum of three samples per core. The segmentation scheme for chemical analyses for these port channels is the same as for the Southern Navigation Channels (South of Port Newark). Table 6-3 provides additional information regarding the coring locations and the associated vertical segmentation scheme.

Sampling for Radiochemical Analyses

As a result of both recurrent and recent dredging activity, it is unlikely that “historical” sediments will be present in the cores obtained from the Port Channels. Therefore, there are no proposed radiochemical analyses for this geomorphic area.

Sub-tidal Flats

There is comparatively less information regarding the sediment deposition rate in the Sub-tidal Flat geomorphic area as compared to the Navigation Channels, where there are more extensive records of bathymetry and volumetric sediment measurements. However, Suszkowski (1978) reported a net sedimentation rate of 0.14 in/yr in "off channel" areas. This translates to an average total deposition of approximately 8.8 inches since 1940.

Sampling for Chemical Analyses

The sampling strategy for the Sub-tidal Flats includes two types of cores: shallow cores with depth sufficient to contain sediments deposited since 1940 (based on reported deposition rates), and a limited number of deeper cores obtained for the purpose of verifying that the sediment deposition rates have not been underestimated. As a result, a total of 28 core locations have been selected, including 19 shallow cores and nine deep cores (Figure 6-1). The coring locations were selected using a quasi-triangular grid (including modifications necessitated by boundary conditions), with additional judgmental samples placed in smaller non-contiguous sub-tidal areas. The locations of the nine deep cores were selected based on professional judgment, taking into account major Sub-tidal Flats within the Phase I SI Study Area and distance from the shoreline - the southwest flat area near Arthur Kill, the area surrounding the CDF, and the northwest flat where additional CDF cells were proposed and contaminated sediments were found at depth.

For the shallow cores, the target penetration is 3.5 ft, which represents approximately five times the depth likely required to reach the 1940 horizon (assuming the reported 0.14 in/yr sedimentation rate). In this case, cores for chemical analyses will be segmented into a 0-0.5 ft surface sample (i.e., BAZ), and three 1-foot segments, as shown below.

Chemical Segmentation Scheme
Sub-tidal Flats (Shallow)

Penetration	Segment 1	Segment 2	Segment 3	Segment 4
3.5 ft	0 – 0.5 ft (BAZ)	0.5 – 1.5 ft	1.5 – 2.5 ft	2.5 – 3.5 ft

For the nine deep cores, the target penetration is 6.5 ft. These cores will be used primarily to verify assumptions regarding the target depth selected for the shallow cores. Data regarding chemical concentrations deeper than this depth are of limited practical value, and as such, these deep cores will be segmented according to the following table.

Chemical Segmentation Scheme
Sub-tidal Flats (Deep)

Penetration	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6
6.5 ft	0 – 0.5 ft (BAZ)	0.5 – 1.5 ft	1.5 – 2.5 ft	2.5 – 3.5 ft	3.5 – 5 ft	5 – 6.5 ft

Table 6-3 provides additional information regarding coring locations and the associated vertical segmentation scheme.

Sampling for Radiochemical Analyses

Samples collected from the Sub-tidal Flat geomorphic area will be analyzed for ^{210}Pb, ^{137}Cs, and ^{7}Be. Radiochemical dating of the Sub-tidal Flat cores is primarily used for verifying the low rates of net sedimentation in these areas, thereby validating the shallow core target depth.

The vertical segmentation scheme for ^{210}Pb and ^{137}Cs dating of the shallow cores includes segments taken at the 0-2, 2-4, 4-6, 8-10, 14-16, 20-22, 26-28, 32-34, and 40-42 inch depths. For the deep cores, segments will be taken at 0-2, 2-4, 4-6, 10-12, 22-24, 34-36, 48-50, 62-64, and 76-78 inch depths. Surface sediments collected from this geomorphic area will also be analyzed for ^{7}Be.

Table 6-4 provides additional information regarding the specific vertical segmentation scheme associated with the radiochemical analyses.

<u>Transitional Slopes</u>

The behavior and stability of sediments (and the associated chemical concentrations) present in the transitional areas between the Navigation Channels and the Sub-tidal Flats is largely unknown. Therefore, the characteristics of the Transitional Slopes are not as fully developed as other geomorphic features presented in the preliminary CSM (Section 3). In considering this geomorphic area for sampling purposes, the following questions became apparent:

- Do the deposition rates in these areas reflect the relatively rapid rates of the main Navigation Channel or the more gradual deposition expected for the Sub-tidal Flats?

- Does the surface sediment chemistry reflect similar inputs as other geomorphic areas; does the partial incision into the bed increase the influence of historically deposited sediments, and; do other mechanisms control in these areas?
- Are these areas a sediment source or sink?
- How, if at all, do sloughing, channel current velocities, and navigation traffic impact the sediment stability of the slopes?

Despite these uncertainties, it is believed that this geomorphic area may play an important role in the Bay's dynamics. Based upon an approximate slope of 3 to 1, the Transitional Slopes are anticipated to extend approximately 100 to 150 ft from the Navigation Channel footprint (Figure 6-1). Bathymetric data obtained during the Phase I SI (Section 6.2) will help better define the width of this zone at various points in the channel.

Sampling for Chemical Analyses

A total of five coring locations were selected to characterize the sediment chemistry along the Transitional Slopes. For comparison purposes, five locations were judgmentally selected to provide a wide spatial coverage and to be paired with a coring location in the Northern Navigation Channel or Southern Navigation Channel (Figure 6-1). To keep the Transitional Slope cores comparable to one another, a target water depth of 15 (+/-2) ft has been selected for the placement of these coring locations, with exact locations to be determined in the field based on judgment and the bathymetric data to be obtained.

Given the unknown nature of the material present in the Transitional Slopes, a target penetration of 5.5 ft has been selected, which, combined with direct (dredging) or indirect (sloughing) lowering of the bed, should encompass the 1940 sediment horizon. Six core segments will be obtained for chemical analyses including the 0 - 0.5 ft surface sample (BAZ), followed by five additional 1-ft samples, as shown below.

Chemical Segmentation Scheme
Transitional Slopes

Penetration	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6
5.5 ft	0 – 0.5 ft (BAZ)	0.5 – 1.5 ft	1.5 – 2.5 ft	2.5 – 3.5 ft	3.5 – 4.5 ft	4.5 – 5.5 ft

Table 6-3 provides additional information regarding coring locations and the associated vertical segmentation scheme.

Sampling for Radiochemical Analyses

Samples collected from the Transitional Slopes will be analyzed for ^{210}Pb, ^{137}Cs, and ^{7}Be. The ^{210}Pb activity will help identify the age of deeper material based on a comparison of the ^{210}Pb activity with that in surficial sediments. Also, discontinuities in sediment deposition over time should be identifiable as discontinuities in the exponential decay rate plot of ^{210}Pb activity with depth. The ^{137}Cs will serve as a binary indicator, with its presence or absence used to identify the approximate depth of the 1954 horizon (or at a minimum, the presence of post-1954 sediments). The vertical segmentation scheme for radiochemical dating and analysis includes segments taken at the 0-2, 2-4, 4-6, 10-12, 18-20, 28-30, 40-42, 52-54, and 64-66 inch depths.

Table 6-4 provides additional information regarding the specific vertical segmentation scheme associated with the radiochemical analysis. Surface sediments collected from this geomorphic area will also be analyzed for ^{7}Be.

Inter-tidal Areas

As with the Sub-tidal Flats, little information is known regarding the sediment deposition rate in the Inter-tidal Areas. The tidal activity in Newark Bay results in inundation of the sediments in the Inter-tidal Areas during high tide and exposure of sediments during low tide. This constant “wetting” and “drying” may influence the depositional and erosional processes differently than sediments in the Sub-tidal Flats. However, in the absence of area-specific depositional rates, Suszkowski’s (1978) reported net sedimentation rate of 0.14 in/yr in “off channel” areas was utilized to determine the segmentation scheme. This net sedimentation rate translates to an average total deposition of approximately 8.8 inches since 1940.

Sampling for Chemical Analyses

A total of three coring locations were selected to characterize the sediment chemistry within the Inter-tidal Areas of Newark Bay. These three locations were judgmentally placed on larger mudflats within Newark Bay that likely comprise the key inter-tidal habitats (Figure 6-1). As described below, three additional cores (002, 025, and 065) will be collected from Inter-tidal Areas, primarily for purposes of source identification. As such, these three Industrial Waterfront cores will be segmented differently, and will be discussed later in this section.

A target penetration of 4 ft has been selected, which should encompass the 1940 sediment horizon when considering Suszkowski’s (1978) net sedimentation rate for “off channel” areas (0.14 in/yr). Four core segments will be obtained for chemical analyses, as shown below.

Chemical Segmentation Scheme
Inter-Tidal Areas

Penetration	Segment 1	Segment 2	Segment 3	Segment 4
4.0 ft	0 – 0.5 ft (BAZ)	0.5 – 1.5 ft	1.5 – 2.5 ft	2.5 – 4.0 ft

Table 6-3 provides additional information regarding coring locations and the associated vertical segmentation scheme.

Sampling for Radiochemical Analyses

Samples collected from the Inter-tidal Areas will be analyzed for ^{210}Pb, ^{137}Cs, and ^{7}Be. Radiochemical dating of ^{137}Cs and ^{210}Pb in the cores is primarily used for determining the rates of net sedimentation in these areas. The vertical segmentation scheme for radiochemical dating of ^{210}Pb and ^{137}Cs includes segments taken at the 0-2, 2-4, 4-6, 8-10, 14-16, 20-22, 26-28, 32-34, and 46-48 inch depths. Additionally, surface sediments collected from this geomorphic area will be analyzed for ^{7}Be.

Table 6-4 provides additional information regarding the specific vertical segmentation scheme associated with the radiochemical analysis.

<u>Industrial Waterfront Areas</u>

As described in Section 3 (CSM), the Industrial Waterfront Area encompasses an area that extends 100 ft from the Newark Bay shoreline. This area constitutes that portion of the Bay most likely affected by constructed pier and shipping facilities, privately dredged channels, POTWs, CSOs, NPDES-permitted discharges, SWOs, and other facilities. Due to the frequent disturbance of these areas (ship propellers, discharge from outfalls, dredging/filling activities), sedimentation rates are expected to vary.

Sampling for Chemical Analyses

A total of nine coring locations were selected to characterize the sediment chemistry within the Industrial Waterfront Areas (six in Newark Bay and three in Hackensack River). These nine locations were judgmentally placed adjacent to potential sources (Figure 6-1). Based on the sedimentation rates previously presented and the available information regarding these potential sources, a target penetration of 6.5 ft was chosen. Six core segments will be obtained for chemical analyses including the 0 - 0.5 ft surface sample (BAZ), followed by three additional 1-ft samples, and two 1.5-ft sample, as shown below.

Chemical Segmentation Scheme
Industrial Waterfront Areas

Penetration	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6
4.0 ft	0 – 0.5 ft (BAZ)	0.5 – 1.5 ft	1.5 – 2.5 ft	2.5 – 3.5 ft	3.5 – 5.0 ft	5.0 – 6.5 ft

There is one exception to the segmentation scheme shown above. Core 012 will be advanced a total of 8 ft in order to verify historical data collected from core PRP-99-02 in 1999 (see Figures 3-5b, 3-6b, and 3-7b in RIWP Volume 1 [Tierra, 2004]). As such, for this core only, an additional segment will be collected from the 6.5-8 ft interval.

Table 6-3 provides additional information regarding coring locations and the associated vertical segmentation scheme.

Sampling for Radiochemical Analyses

Samples collected from the Industrial Waterfront Areas will be analyzed for ^{210}Pb, ^{137}Cs, and ^{7}Be. The vertical segmentation scheme for radiochemical dating of ^{210}Pb and ^{137}Cs includes segments taken at the 0-2, 2-4, 4-6, 10-12, 22-24, 34-36, 48-50, 62-64, and 76-78 inch depths. An additional segment of 94-96 inches will be collected at core 012**.** Additionally, surface sediment (0-1 inch) will be analyzed for ^{7}Be.

Table 6-4 provides additional information regarding the specific vertical segmentation scheme associated with the radiochemical analysis.

6.4 Implementation Procedures

This section presents the actual procedures required to implement the Phase I SI Program. Following a brief discussion of several general activities important in initiating the work, detailed field procedures are provided.

6.4.1 General Field Procedures

6.4.1.1 Pre-Mobilization

Subsequent to USEPA approval of the RIWP, pre-mobilization activities will commence, and include the following:

- subcontractor selection and contracting;
- equipment specification and procurement;
- utility identification and clearing; and
- staffing/general planning.

The task of identifying and clearing utilities is an important one, and will be initiated as early as possible in the process. In conjunction with this, the U.S. Coast Guard (USCG) Captain of the Port will be contacted to coordinate the overall sampling operations, and to identify notification requirements for the Vessel Traffic Service or other public agencies. Additionally, Tierra will meet with the USACE to discuss the current status of the Harbor Deepening Project and any effect it (or any other maintenance dredging activities) may have on the Phase I activities and core locations.

Property access issues and/or permit requests with the appropriate agencies will also be pursued during this period.

6.4.1.2 Mobilization

Mobilization tasks will include the transportation of personnel, supplies, equipment, and subcontractors to the Site, which will be undertaken prior to commencement of the field activities specified previously in this section. Other important activities to be conducted during mobilization are described below.

<u>Health and Safety</u>

Health and safety requirements applicable to the persons entering the secured location or involved in the Phase I SI Program are described in RIWP Volume 3 (Tierra, 2005) (i.e., the HASCP). Among other things, the HASCP describes personnel medical requirements, known hazardous chemicals present at the Site, exposure limits, personnel protection requirements, and Work Areas.

<u>Site Facilities</u>

Tierra's Lister Avenue property (also known as the Sample Processing Area) will be used for the storage and staging of equipment and land-based vehicles utilized during the field investigation. This location will include decontamination facilities, sample handling/processing facilities, a field office, and storage facilities. Access to this location will be controlled. No one shall enter the area without appropriate authorization.

Decontamination Facility

A facility will be set up for decontamination of equipment used in the field investigation. The decontamination area will be located at the Sample Processing Area.

Tide Gage Installation

As discussed in Section 6.2.2, a tide gage will be installed at the Site during the mobilization process. SOP No. 4 – Tide Gage Installation, describes the installation procedure.

6.4.2 BAZ Investigation

The BAZ investigation will be conducted prior to the bathymetry survey and core collection activities in accordance with SOP No. 12 – Sediment Profile Imaging. This investigation will consist of obtaining a minimum of two acceptable SPI images at 14 locations within the Phase I Study Area. Table 6-3 provides the coordinates of the SPI locations. While in the field, a preliminary assessment will be made to determine the quality of the images; any unacceptable locations will be resampled.

Upon obtaining acceptable SPI images, three sediment grab samples will also be collected at each of the 14 locations within a 50-foot radius of the SPI location. The grab samples will be photographed and visually examined for sediment texture, sediment color, and benthic invertebrate activity while on the sampling vessel. Sediment will be immediately returned to the Bay following examination and photographing. The sediment collection work will be performed in accordance with SOP 11 – Sediment Collection Using a Grab Sampling Device.

Activities will be documented in the BAZ Investigation Form and Logbook in accordance with SOP No. 1 – Field Documentation.

6.4.3 Bathymetric Survey Procedures

The bathymetric survey will be conducted in accordance with SOP No. 10 - Bathymetric Surveying, using a single beam, dual frequency fathometer for depth measurement, and a differential global positioning system (DGPS) to record horizontal positioning**.** The survey equipment will measure and record soundings along survey lines oriented perpendicular to the Bay (unless otherwise noted). Soundings will be acquired on a continuous basis along each survey line, at approximately 0.25-mile intervals.

Following completion of the field survey, plan view sounding sheets will be prepared with soundings corrected to NAVD88, plotted at approximately 10-ft intervals along each survey line. These sheets will be prepared by the bathymetric survey contractor using AutoCad or equivalent at a scale of 1 inch=1,000 ft and will show the Navigation Channel limits, aids to navigation, control points, and the New Jersey State Plane Coordinate System (NAD 83). The bathymetric survey information will be used in preparation of the Newark Bay RI Report. The exact mapping may change based upon the data collected.

6.4.4 Sediment Sampling Procedures

The following text describes the procedures to be followed in collecting and processing the sediment cores for analyses. Appendix B contains the referenced field SOPs.

6.4.4.1 Decontamination of Equipment

Decontamination is the process of neutralization, washing, and rinsing exposed surfaces of equipment to minimize or eliminate the potential for chemical migration and/or cross-contamination. Chemicals can be brought to a sampling location and/or introduced into the sampling media by equipment previously used at other sites or locations. Trace quantities of these materials can lead to false positive analytical results and, ultimately, to an incorrect assessment of the site conditions. Decontamination of sampling equipment (e.g., core tubes, water bottles, and other sampling equipment) and field support equipment (e.g., coring barge) is required to minimize or eliminate cross-contamination.

Equipment coming into contact with water and/or sediment from Newark Bay during the course of the field activities will require decontamination. Three levels of decontamination (e.g., solvent, soap and water, or Bay water decontamination) will be performed based on the usage of the sampling equipment. Sampling equipment that will come into contact with sediments will be decontaminated using the procedure approved by USEPA Region 2 (USEPA, 1989) prior to sampling. Decontamination methods for other equipment that will not come into contact with sediment for chemical analysis include either a wash with low-phosphate detergent (e.g., Alconox) and tap water or a wash with Newark Bay Water. Descriptions of the three classifications and procedures are presented in SOP No. 3 - Decontamination.

In addition to the classifications described above, new equipment will also be decontaminated before use to remove could potential fabrication residuals/chemicals (SOP No. 3 – Decontamination).

6.4.4.2 Positioning

A DGPS unit will be used to determine the position of each core. Horizontal data will be presented in New Jersey State Plane coordinates (NAD 83). Coordinates for each planned boring are presented in Table 6-3 and illustrated in Figure 6-1. As noted previously, bathymetric data obtained prior to the start of sediment sampling will be used to position the exact location of the Transitional Slope cores. Vessel and sampler positioning will be conducted in accordance with SOP No. 5 –Positioning.

After determining that the vessel is positioned directly over the intended coring location, core collection will be performed in accordance with the procedures specified in either SOP No. 6 or 7 (Hand Coring or Vibracoring, respectively), depending upon conditions in the field. At locations with radiochemical analyses, a sediment grab sample will be obtained in accordance with the procedures specified in SOP No. 11 – Sediment Collection using a Grab Sampling Device after collecting the appropriate number of cores.

6.4.4.3 Sediment Sample Collection

To collect sediment samples that meet the stated DQOs, hand coring, vibracoring, or grab sampling procedures will be used. Hand coring will be performed in accordance with SOP No. 6 – Sediment Collection Using Hand Coring Device, while vibracoring activities will be performed in accordance with SOP No. 7 – Sediment Collection Using Vibracoring Device. Grab sampling will be performed in accordance with SOP No. 11 – Sediment Collection Using Grab Sampling Device. Field conditions and professional judgment will be used to determine which method is appropriate for a given geomorphic area and location. The bathymetric survey data obtained prior to the start of sediment sampling will be useful for this purpose as well.

Up to two cores will be collected at all 69 locations. Sediments will be retained in a polybutyrate core tube of nominal 4 inches outer diameter. As described in Section 6.3.1, for the 18 locations where only chemical samples are to be collected, the appropriate sample volume will be obtained from a single core (“primary core”), advanced to the target penetration (Table 6-3) or refusal if the target penetration cannot be reached. Processing of chemical cores will be done in accordance with SOP No. 8 – Core Processing.

At locations where both chemical and radiochemical (i.e., ^{210}Pb and/or ^{137}Cs) samples are to be collected (i.e., 51 locations), sediment cores of acceptable penetration and recovery (as described in SOP Nos. 6 and 7) will be obtained to provide adequate sample volume. One core ("primary core") will be advanced to the targeted penetration (Table 6-3) or refusal if the target penetration cannot be reached. A second core, necessary to provide additional volume for the BAZ sample, will be advanced to a target penetration of 1.5 ft to provide a representative and undisturbed surface sediment interval. Where two cores are collected at a given sampling location, they will be co-located and offset within 10 ft of each other, to the extent possible. For a given core, the field crew will attempt to obtain the targeted penetration and recovery no more than three times (Table 6-3). In cases where all three attempts are unsuccessful, the PM will be contacted and professional judgment and field conditions will be used to determine if additional cores should be attempted.

An additional radiochemical parameter (^{7}Be) will be determined through the collection of a sediment grab sample (as described in SOP No. 11 – Sediment Collection Using Grab Sampling Device) at 51 locations.

Sediment for chemical and radiochemical analyses will be collected from the same core ("primary core"). The core will be split lengthwise, and sediment for chemical analyses will be obtained from one half of the core, while material for ^{210}Pb, and ^{137}Cs analyses will be obtained from the other half (SOP No. 8 – Core Processing). Additionally, an approximate 0-1 inch segment will be collected from the sediment grab sample for ^{7}Be analysis.

A brief discussion of the two core collection and grab sample procedures considered for use during this program is provided below.

Vibracoring

Vibracoring is the process of obtaining a continuous, well-preserved core from water-saturated, unconsolidated sediment. Vibracoring will be conducted from a vessel designed for deployment of the vibracorer and for the installation of the vibracorer and ancillary equipment. Prior to commencement of coring activities, the vessel will be positioned in accordance with SOP No. 5 –Positioning. Details of the vibracoring procedure are presented in SOP No. 7 – Sediment Collection Using Vibracoring Device.

Hand coring

Hand coring devices may be used to collect surface and subsurface sediment samples in locations such as shallow areas and sub-tidal flats. Details of the hand coring procedures are presented in SOP No. 6 – Sediment Collection Using Hand Coring Device.

Grab Sampling

Grab sampling devices may be used to collect surface sediment samples for purposes of ^{7}Be analyses. Details of the grab sampling procedures are presented in SOP No. 11 – Sediment Collection Using Grab Sampling Device.

6.4.4.4 Core Processing and Sample Collection

Following collection activities, the cores will be brought to the on-shore Sample Processing Area for logging, photologging, and sample preparation. Core processing procedures are presented in SOP No. 8 – Core Processing, and will be followed during sample collection to ensure that there is no cross-contamination from other sections of the core, or from the sampling equipment. Sampling equipment used during sample processing and collection will be decontaminated in accordance with SOP No. 3 – Decontamination.

Once the sample intervals have been identified, the sediments within the core will be observed and logged as described in SOP No. 8 – Core Processing. The exact processing procedures are dependent upon whether the core contains high water content sediments. Samples for chemical and radiochemical (^{210}Pb and ^{137}Cs) analyses will then be collected from the predetermined intervals presented in Section 6.3.2. Samples for VOCs will be taken directly from the core using the EnCore® sampling system, or similar system. Samples for other chemical analyses will be homogenized in a decontaminated stainless steel bowl prior to placing into sample jars. As discussed in SOP No. 11- Sediment Collection Using Grab Sampling Device, the 0-1 inch interval will be collected from the grab sample and placed in the appropriate sample container on the sampling vessel.

SOP No. 8 also presents the sample segments if penetration less than the target is achieved. Additionally, if limited sample volume is recovered, the chemical analysis hierarchal prioritization provided in Table 6-5 will be followed. Table 6-5 also presents the desired minimum sample weights for each analyses.

Waste sediment and associated disposable equipment generated during core processing will be disposed of according to SOP No. 9 - Management and Disposal of Residuals.

Table 6-6 presents sample bottle and preservative specifications required for sediment samples collected for chemical and radiochemical analyses during the IWP activities.

6.4.4.5 Field QC Sample Collection

QC samples will be collected to determine the accuracy, precision, representativeness, comparability, and completeness of both field and laboratory procedures. Rinsate blanks and field duplicates samples will be collected and analyzed for chemical and radiochemical analyses, while PE and trip blank samples will be collected and analyzed for PCDDs/PCDFs and VOCs, respectively. Section 6.7 of this IWP provides detailed descriptions of the type and frequency of field QC samples to be collected.

Specific procedures to be used in decontamination of field equipment are provided in SOP No. 3 - Decontamination. After the equipment is decontaminated and prior to reuse, a rinsate blank will be collected as described in Section 6.7.1.1.

Table 6-7 presents sample collection and handling requirements for rinsate blanks collected for chemical analyses during this IWP.

6.4.4.6 Field Documentation

Information collected in the field through visual observation or measurement will be recorded in a logbook and on prepared forms. Such information will be periodically reviewed by the PM and/or their designees. Details of the field documentation requirements and pre-prepared forms are presented in SOP No. 1 – Field Documentation.

6.5 Sample Handling and Custody Requirements

This section describes procedures for sample identification, chain of custody, and field documentation for collected samples. The purpose of these procedures is to maintain the quality of samples during collection, transportation, and storage prior to laboratory analysis. This section presents custody procedures to be followed prior to, during, and after sample collection by field and laboratory personnel.

6.5.1 Sample Handling and Shipment

The handling of samples from the time of collection through transportation to the laboratory will be conducted in accordance with SOP No. 2 – Containers, Preservation, Handling, and Tracking of Samples for Analysis. A summary of the procedures provided in this SOP is presented below.

In general, a sample is under the sampler's custody if one or more of the following criteria are met:

- The sample is in the sampler's possession;
- The sample is in the sampler's view after being in possession;
- The sample was in the sampler's possession and then locked up to prevent tampering; or
- The sample is in a designated secure area.

A label will be attached to each bottle used for sampling. When practical, the company-specific project number (if appropriate), sample matrix, laboratory designation, and sample identification code will be typed or printed onto the label before sampling. An example pre-printed label is included in SOP No. 2 – Containers, Preservation, Handling, and Tracking of Samples for Analysis.

Samples will be packaged and shipped in accordance with SOP No. 2 – Containers, Preservation, Handling, and Tracking of Samples for Analysis. A summary of the handling procedures provided in SOP No. 2 is presented below.

Sample containers will be properly labeled and the sample container lids will be closed and secured with tape prior to packaging and shipment. Samples ready for packaging will be placed in individual sealable plastic bags. An appropriate number of bagged samples will be placed in a shipping container (e.g., cooler with lid), leaving adequate space for packing material and ice. Packing material will be made of an inert substance and will be capable of eliminating or limiting damage to the sampling containers during transit to the laboratory. Ice, or an ice substitute, will be secured in sealable plastic bags to prevent leaking of condensation or meltwater, and placed around the samples in the shipping container. A temperature blank provided by the analytical laboratory with each shipping container will be included. The completed chain of custody and other necessary paperwork will be sealed in a plastic bag and then secured to the inside of the shipping container lid.

Once packed, the shipping container lid will be closed and secured with a signed and dated custody seal. The custody seal will be placed in such a manner as to show whether or not the lid was opened or tampered with during transit to the laboratory. After applying the custody seal, the container lid will be taped shut. If a laboratory courier is being used, the container is ready for shipment. However, if a commercial shipping company is used, the airbill or packing/shipping paperwork should be affixed to the top of the container and relevant tracking information should be recorded on the chain of custody form prior to sealing the shipping container.

6.5.2 Chain of Custody Procedures

The handling of samples from the time of core collection through transportation of samples for laboratory analysis will follow chain of custody procedures. Field personnel will maintain the collected samples following proper custody procedures until they are picked up by the laboratory courier or a shipping container is sealed with a custody seal and received by a representative of a shipping company. In circumstances where a shipping company is used, the airbill or shipping/packing slip will act as documentation of custody.

Detailed chain of custody procedures to be used during core collection and sample processing activities are provided in SOP No. 2 – Container, Preservation, Handling, and Tracking of Samples for Analysis and summarized below.

6.5.2.1 Laboratory Sample Receipt

Upon receipt at the laboratory, laboratory personnel will inspect the samples for integrity, check the shipment against the chain of custody, and document discrepancies on the chain of custody form. Each shipping container's custody seal will be checked for evidence of tampering. If evidence of tampering is found, laboratory personnel will note it on the chain of custody and contact the FC or QAO. If the custody seal is intact, laboratory personnel will measure the temperature within each shipping container and record the measurement on the chain of custody. If the shipping container's temperature exceeds the target temperature of 4° Celsius (°C), the laboratory will contact the FC or QAO to determine further action.

The integrity of the individual sample containers will also be checked. If laboratory personnel identify a broken sample container, it will be noted on the chain of custody and the FC or QAO will be contacted. If the custody seal is intact, the temperature is within the acceptable range, and the sample containers are intact, the laboratory will proceed with the analysis procedures requested.

Once the field chain of custody has been verified complete, the samples will be logged-in to the laboratory's computerized tracking system, which assigns a unique lab ID number to each sample. The analyses required are specified by codes assigned to the sample at log-in. Labels containing the laboratory sample number are generated and placed on the sample bottles.

A work order will be created, including a summary of the sample analyses to be completed. Copies of the work order will be distributed to the appropriate laboratory managers.

After the samples are labeled, they will be moved to locked refrigerators where they will be maintained at a target temperature of $4^{o}C$. Samples to be analyzed for volatile organics will be stored separately to minimize the risk of cross-contamination. Access to the refrigerators will be limited to members of the sample management department.

Laboratory personnel are responsible for the care and custody of samples from the time they are received, either by a laboratory courier at the Site or via shipment directly to the laboratory facility, until the samples are returned to client for ultimate disposal.

6.5.2.2 Laboratory Internal Chain of Custody Process

The field chain of custody is complete when the samples are received at the laboratory. Laboratory personnel will begin and maintain an internal chain of custody once the samples have been received. This lab-specific chain of custody will document the handling and processing of samples from receipt at the laboratory through final disposal.

When samples are required for analysis, the analyst will fill out a sample request form and give it to the Sample Custodian, who will locate the samples, sign and date the internal chain of custody, and relinquish custody to the analyst. The analyst in turn will sign and date the chain of custody to accept custody of the sample. When the analyst is finished with the sample, the unused portion will be returned to the Sample Custodian. Both the analyst and Sample Custodian will sign and date the chain of custody. The sample will then be returned to secure storage. In the event that the entire sample is depleted during analysis, a notation of "sample depleted" or "entire sample used" will be made on the chain of custody.

Sample extracts and digestates maintain their own chain of custody. Sample extract custody will begin with an extraction, digestion, or distillation log, as appropriate to the analysis. Upon completion of the preparation, an extract chain of custody form will be initiated. The extracts will then be given to the analyst with the time and date noted on the form. The analyst will place the extracts in designated secure storage areas. Transfers of the extract into and out of the storage area will be noted on the chain of custody. Samples and sample extracts will be maintained in secure storage. Samples will be held for a minimum of 90 days and extracts for 365 days after data submission, then samples will be returned to Tierra for disposal. The Sample Custodian will note the date of return to Tierra on the chain of custody.

Upon completion of the requested analyses, laboratory documentation, including but not limited to sample results, field and internal chain of custody, instrument calibrations, extraction and dilution information, and gas chromatography/mass spectrometry logs will be provided to the data validator as part of the final data deliverable package upon completion of the sample analysis and appropriate lab QA/QC. This documentation will meet the requirements further detailed in Section 5.4.2. Data validation will be completed to assess laboratory compliance with the procedures described in the IWP, completeness of the analytical data package, and fulfillment of project requirements. Additional information pertaining to data validation is presented in Section 8 of this IWP.

6.6 Analytical Procedures

6.6.1 Analytical Methods

This section describes the analytical methods to be used during the implementation of the IWP. The QA/QC methodologies specified in this section are set forth in "Test Methods for Evaluating Solid Wastes, SW-846." Table 6-8 presents a summary of the SW-846 and other analytical methods selected for use as part of this IWP. The methods stated herein will be implemented by personnel experienced and trained in the use and application of the methods. If, because of matrix effects or other unforeseeable circumstances, the stated methods are unable to provide satisfactory results, other analytical methods may be utilized to successfully complete the analysis. Laboratories will provide written notification to the FC and QAC describing modifications to the required method prior to analysis. Laboratories will receive written approval from the QAC of such modifications prior to analysis.

The extraction and analytical methods to be used are specified in Table 6-8. Copies of these methods are included as Appendix C of this IWP. The methods will be performed as stated in the referenced procedures. It is the laboratory's responsibility to ensure that the analyses are performed by the referenced method, and changes made to the copies of the methods included in the appendices to this report do not constitute changes to the analytical methods. Laboratories retained to perform analyses of samples shall strictly follow these procedures. For each analytical method, the target analytes and quantitation or detection limit requirements are listed in Tables 5-1 through 5-10 of this IWP. The accompanying data verification and validation procedures are provided in Section 8.

6.6.1.1 Semivolatile Organics

Semivolatile organics for aqueous samples will be extracted by Method 3510C, solid samples will be extracted by Method 3550B, with both matrices analyzed by Method 8270C as specified in Table 6-8. The method employs gas chromatography/mass spectrometry for determining the semivolatile organics in sample extracts. A copy of the analytical method and the extraction method are included in Appendix C of this IWP. The specific TCL and SQL requirements are specified in Table 5-1.

The limits for MS/MSD accuracy and precision for semivolatile organics in aqueous and solid matrices are laboratory-specific and will be developed following the procedures outlined in Section 8.0 of the analytical method (Method 8000B, in Appendix C). Likewise, LCS and surrogate %R limits will be developed following the procedures outlined in Section 8.0 of Method 8000B. However, laboratory in-house acceptance limits will not exceed the %R ranges listed below for surrogate and LCS standards.

QC Check Standard	Acceptance Range
LCS (all MS compounds)	70 - 130%
Surrogate	10 - 150%

6.6.1.2 Pesticides

The extraction method for organochlorine pesticides in sediment will be Method 3550B, the extraction method for pesticides in water will be Method 3510C as specified in Table 6-8. The analysis method (Method 8081) employs gas chromatography utilizing an election capture detector. A copy of the extraction and analytical methods appears in Appendix C of this IWP. The analytical procedure will follow Method 8081. The specific TCL and SQL requirements are listed in Table 5-2.

Detected pesticides will undergo confirmatory analysis on a chemically dissimilar second column. Fully compliant analyses including QA/QC check standards will be processed for both primary and confirmatory analyses.

The limits for MS/MSD accuracy and precision for specific pesticide analytes in aqueous and solid matrices, are laboratory-specific and will be developed following the procedures listed in Section 8.0 of Method 8000B (Appendix C). Likewise, surrogate %R limits will be developed following the procedures outlined in Section 8.0 of Method 8000B. However, laboratory in-house acceptance limits for surrogate recovery will not exceed 30 – 150%. Per Method 8081, limits for accuracy (%R) for the LCS are 70 – 130%.

6.6.1.3 Aroclor PCBs

The extraction method for multi-component PCBs for aqueous samples will be Method 3510C and the extraction method for PCBs in sediment samples will be 3550B, as specified in Table 6-8. The analysis method (Method 8082) employs gas chromatography utilizing an electron capture detector. A copy of the extraction and analytical methods appear in Appendix C of this IWP.

The specific TCL and SQL requirements are specified in Table 5-3.

Detected PCBs will undergo confirmatory analysis on a chemically dissimilar second column. Fully compliant analyses including QA/QC check standards will be processed for both primary and confirmatory analyses. An MS for PCBs will be performed by spiking with Aroclor 1254. Details of the analytical procedure are presented in Appendix C of this IWP.

The limits for MS/MSD accuracy and precision for specific Aroclor analytes in aqueous and solid matrices, are laboratory-specific and will be developed following the procedures listed in Section 8.0 of Method 8000B

(Appendix C). Likewise, surrogate %R limits will be developed following the procedures outlined in Section 8.0 of Method 8000B. However, laboratory in-house acceptance limits for surrogate recovery will not exceed 30 – 150%. Per Method 8082, limits for accuracy (%R) for the LCS are 70 – 130%.

6.6.1.4 PCB Congeners and Homologues

The extraction/analysis method for PCB congeners and homologues for water and sediment will be USEPA Method 1668A as specified in Table 6-8. The method employs high resolution gas chromatography/mass spectrometry (HRGC/ HRMS) and provides for positive detections at relatively low detection limits. A copy of the method appears in Appendix C of this IWP. The specific TCL and SQL requirements are specified in Tables 5-4 and 5-5.

The limits for MS/MSD accuracy (%R) for PCB congeners in aqueous and solid matrices are 60 - 140% (valid only when the spike level is between 25 – 400% of the reported sample concentration). The acceptance limit for MS/MSD precision (RPD) is ±50%. Internal standards will be added to each sample prior to sample preparation. Internal standard recoveries will be between 25 – 150%. Finally, the method required ongoing precision and recovery standard (OPR) will have observed final concentrations for each target analyte within the acceptance ranges listed on Table 6 of the analytical method.

6.6.1.5 Chlorinated Herbicides

The extraction and analysis method for chlorinated herbicides for water and sediment will be Method 8151A, as specified in Table 6-8. This method employs a gas chromatograph utilizing an electron capture detector. A copy of the analytical method appears in Appendix C of this IWP. The specific TCL and SQL requirements are specified in Table 5-6.

Detected herbicides will undergo confirmatory analysis on a chemically dissimilar second column. Fully compliant analyses including QA/QC check standards will be processed for both primary and confirmatory analyses.

The limits for MS/MSD accuracy and precision for chlorinated herbicides for aqueous and sediment matrices is laboratory specific and will be developed following the procedures outlined in Method 8000B. Limits for accuracy of surrogate recoveries are calculated by the laboratory from historical data as specified in Method

8000B. However, laboratory derived in-house acceptance limits for surrogate and MS recoveries are to fall within the %R ranges listed below.

QC Check Standard	Acceptance Range
Surrogate	50 - 120%
MS	60 - 140%

Per Method 8151A limits for accuracy (%R) for the LCS are 70 - 130%.

6.6.1.6 Dioxin and Furan Isomers

Dioxin and Furan Isomers (PCDDs and PCDFs) will be analyzed by Method 1613, Revision B (1613B), October 2001, as specified in Table 6-8. A copy of the analytical method is included in Appendix C of this IWP. This method uses high resolution gas chromatography/mass spectrometry in the SIM mode for the detection and quantitation of PCDDs (tetra through octachlorinated homologues) and PCDFs (tetra through octachlorinated homologues) at part per trillion (ppt) concentrations for sediment and picograms per liter (pg/L) concentrations for aqueous samples. USEPA Method 1613B is considered preferable to SW-846 Method 8290. Method 1613B incorporates additional labeled internal standards for 2,3,7,8-substituted isomers except the octachlorinated dibenzofuran, providing more accurate and reliable results. Also, historical PCDD/PCDF data from past sampling events (*e.g.*, 1989 through 2000) in Newark Bay and its tributaries collected by USEPA Region 2 and others used Method 1613A for PCDD/PCDF analysis. The target compounds to be determined by this method and associated SQLs are listed in Table 5-7.

The limits for MS accuracy for PCDDs/PCDFs analyses in aqueous and sediment matrices are 60 – 140%. Labeled analog standards added to each sample prior to preparation for analysis will have calculated percent recoveries within the acceptance range (25 – 150%). Finally, initial precision and recovery standards, ongoing precision and recovery standards, and the calibration verification standards (VER) will fall within the acceptance ranges provided on Table 6 of Method 1613B.

6.6.1.7 Metals and Cyanide

As specified in Table 6-8, the cold vapor atomic absorption (CVAA) technique (SW-846 7470 or 7471A as appropriate) will be used for mercury analyses. Inductively coupled plasma emission spectroscopy (ICP) (SW-846 6010B) will be used to quantitate the remaining metal target analytes. Titrimetric or colorimetric methods

(SW-846 9010B, 9013 or 9014) will be used for cyanide. Copies of the preparation methods and analytical methods for TAL inorganics and cyanide are included in Appendix C of this IWP. The specific TCL and SQL requirements are specified in Table 5-8.

The limits for MS and LCS accuracy (%R) for cyanide in aqueous and solid matrices should be laboratory specific and developed according to USEPA SW-846 procedures. Likewise, analytical duplicate precision (RPD) acceptance limits are laboratory specific and are developed according to USEPA SW-846 procedures. However, laboratory in-house acceptance limits will not exceed the %R ranges and/or RPDs listed below by QC category.

QC Check Standard	Acceptance Range
MS (%R)	75 - 125%
LCS (liquid) (%R)	80 - 120%
Duplicate (RPD)	$\pm$ 20%

The acceptance range for MS accuracy (%R), for target analyte list (TAL) metals regardless of the analytical technique used for both solid and aqueous matrices is 75-125%. Likewise, sample duplicate determinations should exhibit precision (RPD) of ±20%. Finally, LCS analyses will demonstrate acceptable recovery as described in the individual analytical methods.

6.6.1.8 Total Extractable Petroleum Hydrocarbons

TEPH will be analyzed by the NJDEP Office of Quality Assurance Analytical Method OQA-QAM-025-10/91 as specified in Table 6-8 with the following specific requirements. The extraction solvent used will be methylene chloride. Aqueous samples will be extracted either with a separatory funnel or by a continuous liquid-liquid extraction. The analytical results reported will include those hydrocarbons within the C_8 to C_{40} range. Integration of the chromatographic peaks for these hydrocarbons will include peak areas above the baseline. Quantitative results will be based on a five level calibration curve using the external standard technique. A representative TEPH standard, #2 Diesel should be used to perform the instrument calibration. Two surrogate compounds (chlorobenzene and ortho-terphenyl) will be added to each sample. A copy of the NJDEP Method is presented in Appendix C of this IWP.

The limits for MS/MSD accuracy for TEPH analyses in aqueous and sediment matrices are 40 - 140 %. The acceptance range for MS/MSD precision (RPD) in the aqueous matrix is ±20%, and is ±35% in the solid matrix. Limits for accuracy (%R) for the LCS are 70 - 120%. The Surrogate Standard recovery acceptance windows are 60-120%.

6.6.1.9 Volatile Organics

Volatile organics in aqueous and solid samples will be analyzed using Method 8260B, as specified in Table 6-8. The method employs a gas chromatograph/mass spectrometer for determining the volatile organics in water and sediment sample matrices. A copy of the analytical method is included in Appendix C of this IWP. The specific TCL and SQL requirements are specified in Table 5-10.

The limits for MS/MSD accuracy and precision for volatile organics in aqueous and solid matrices are laboratory-specific and will be developed following the procedures outlined in Section 8.0 of the analytical method (Method 8000B, in Appendix C. Likewise, LCS and surrogate %R (recovery) limits will be developed following the procedures outlined in Section 8.0 of Method 8000B. However, laboratory in-house acceptance limits will not exceed the %R ranges listed below for surrogate and LCS standards.

QC Check Standard	Acceptance Range
LCS (all MS compounds)	70 - 130%
Surrogate	10 - 150%

6.6.1.10 Organotins

Organotin analyses will be performed using the STL Standard Operating Procedures specified in Table 6-8 and included in Appendix C of this IWP. Specific organotin target analytes and SQL requirements are provided in Table 5-9.

The acceptance limits for accuracy (MS/MSD, LCS and surrogate standards) are provided in Table 1 of the stipulated STL Standard Operating Procedure LM-GC-Alkyltins. Likewise, acceptance criteria for laboratory duplicate determinations (RPD of ± 30%), is also provided in Table 1 of SOP LM-GC-Alkyltins.

6.6.1.11 Other Analyses/Parameters

TOC and radiochemistry analyses of solid samples will be performed using the methods specified in Table 6-8. Copies of analytical methods for TOC and radiochemistry are provided in Appendix C to the IWP.

The limits for accuracy for the TOC analyses are 50 - 150%. The limits for precision, based on RPD between duplicate analyses, are 20% for aqueous samples and 35% for sediment samples.

The limits for accuracy for ^{210}Pb, ^{7}Be, and ^{137}Cs analyses are 70 - 130%. The limit for precision, based on comparison of duplicate analyses, is activity overlap of two sigma bands.

The specific SQL requirements for TOC and radiochemistry are specified in Table 5-9.

6.6.2 Quantitation Limits

The target analytes for each of the specified analytical methods and the required quantitation/detection limits for each of the target analytes are listed in Tables 5-1 through 5-10.

With the exception of the PCDD/PCDF, metals, and cyanide analyses, the laboratory will demonstrate that the reporting SQL for each analyte on a "clean" matrix (i.e., blank) is less than or equal to the required quantitation limits listed in Tables 5-1 through 5-10. The laboratory's SQL for each organic analyte will be substantiated by the laboratory’s MDL for that analyte. No analytical results shall be reported as detectable if calculated concentrations are less than the laboratory's MDL. The laboratory will report non-detects for organics at the SQL. If the calculated concentration is greater than the MDL but less than the SQL, the positive value shall be reported and flagged (G).

For the metals and cyanide analyses, the laboratory's SQL on a clean matrix for an analyte will be less than or equal to the required SQL for that analyte listed in Table 5-8. The laboratory’s SQL for each analyte will be three to five times the laboratory’s IDL for that analyte. The laboratory will report non-detects for inorganics at the IDL. If the calculated concentration is greater than the IDL but less than the SQL, the positive value shall be reported and flagged (B).

The detection limits for PCDDs/PCDF are sample-specific per the analytical method. The detection limits on a clean matrix will be less than the representative quantitation limits listed in Table 5-7.

Detection limits for PCDD/PCDF non-detect results are to be calculated in accordance with the following procedure:

1. Calculate a sample-specific estimated detection limit for each 2,3,7,8-substituted congener for which the Selected Ion Current Profile indicated that any of the peaks was not found to be present with a signal to noise ratio greater than 2.5:1.

   Use the equation below to perform the estimated detection limit calculation:

   For Water/Liquid:

$$EstimatedDetectionLimit = \frac{2.5\ x\ Hx\ x\ Qis}{His\ x\ RR\ x\ V}$$

   Where:

   Hx = The height of the noise at the retention time of the quantitation ion of the 2,3,7,8-substituted congener of interest; and

   His = The peak height of the quantitation ion of the appropriate internal standard.

   Qis, RR, and V are the quantity of internal standard, the relative response, and the volume of sample, respectively.

2. Calculate an Estimated Maximum Possible Concentration (EMPC) for 2,3,7,8-substituted congeners that had signal to noise ratios for the quantitation and confirmation ions greater than 2.5:1, but for which interferences caused the result to fail some other qualitative identification criterion.

   Use the equation below to perform the EMPC calculations:

   For Water/Liquid:

$$EMPC = \frac{Ax\ x\ Qis}{Ais\ x\ RR\ x\ V}$$

Where:

Ax = Area of the quantitation ion or confirmation ion for the 2,3,7,8-substituted congener of interest; and

Ais = Area of the quantitation ion for the labeled compound.

Qis, RR, and V are defined above.

Note: For the calculations of EMPC, the lower area of the quantitation or confirmation ion is used. The use of lower EMPC will more accurately reflect the possible concentration of the PCDD/PCDF congeners.

6.6.3 Analytical Chemistry and Radiochemistry Testing Laboratories

Analytical laboratories will be used for chemical analyses during IWP activities. Depending upon the analyses required, the following laboratories will be used:

Laboratory for Congener PCBs and PCDD/PCDF analyses:

- Alta Analytical Laboratory Inc. – El Dorado Hills, CA

Laboratory for radiochemistry analyses:

- Paragon Analytics, Inc. – Fort Collins, CO

Laboratory for Geotechnical analyses:

- Particle Technology Laboratory, Ltd. – Downers Grove, IL

Laboratory for Organotins analyses:

- STL Burlington – Colchester, VT

Laboratory for other chemical analyses:

- Lancaster Laboratories, Inc. – Lancaster, PA

Each of the laboratories identified for Congener PCB, PCDD/PCDF and other chemical analyses have a documented quality system that complies with *EPA Requirements for Quality Management Plans (QA/R-2)* (USEPA, 2001b). The radiochemistry laboratory operates based on a written Quality Control Manual that is consistent with the guidelines shown in *Handbook for Analytical Quality Control in Radioanalytical Laboratories* (USEPA, 1987). Copies of each laboratory's QA/QC manuals, audit reports, current state certifications, and the latest state performance evaluation results will be provided prior to initiation of field sampling activities.

6.7 Quality Control

Internal QC procedures are designed to document the overall quality of data. Two types of QC checks (field and laboratory) will be employed to evaluate the data quality. The QC checks represent the controlled samples introduced into the sample analysis stream that are used to validate the data and to calculate the accuracy and precision of the chemical analysis program.

Field QC checks are accomplished by submitting controlled samples that are introduced to the laboratory from the field. Two types of control samples will be used: blanks (e.g., rinsate blanks) and field duplicates. Field duplicates are submitted "blind" to the laboratory. These blind samples will be noted in the logbook and given a unique sample number that does not indicate to the laboratory that the sample is a QC check.

Laboratory QC checks are accomplished through the analysis of initial and continuing calibration checks, blanks (laboratory method blanks), duplicates (laboratory replicates), calibration standards, spikes (surrogate spike, MS/MSD), and system performance checks (LCS, interference correction samples, etc.).

The level and types of QC check samples that may be introduced into the analysis program are described below. At a minimum, the QC required in the analytical methods will be followed by the laboratory. The QA/QC samples described will be included in every sample lot. An SDG will consist of no more than 20 samples of the same matrix for the organic, cyanide, radiochemistry, and metals analyses, collected over a period of time not to exceed seven days. QA/QC samples except those submitted "blind" should be excluded from the count of 20 samples.

For laboratory, trip (volatiles only), and rinsate blanks in which "analyte-free" water is required, the following criteria for analyte-free reagents (e.g., water, Ottawa sand, solvent) shall be used:

Semivolatile organics	<SQL
Pesticides	<SQL
PCB Congeners	<SQL
Chlorinated Herbicides	<SQL
Metals and Cyanide	<SQL
PCDDs/PCDFs	<SQL
Volatile organics	<SQL

Conventional Parameters	<SQL
Aroclor PCBs	<SQL
Organotins	<SQL

The analyte-free water or solvent utilized during field operations will be analyzed prior to use, demonstrating acceptability.

6.7.1 Field Quality Control Checks

The types of field QC samples to be collected as part of this IWP are listed in Table 5-11. The frequency of collection of field QC samples is shown in Table 5-12.

6.7.1.1 Rinsate Blanks

Rinsate blanks are blanks collected by pouring deionized analyte-free water or solvent, whichever is appropriate to the chemicals of interest (i.e., solvent used in equipment decontamination process), over the sampling equipment after it has been decontaminated and prior to use in the field. Rinsate blanks are often referred to as equipment blanks or as decontamination procedure blanks. Rinsate blanks are submitted for testing for each type of sampling equipment used each day a decontamination event is carried out (not to exceed one per day). Rinsate blanks are used to check for sample contamination caused by reuse of decontaminated sampling equipment, as well as the sampling process and transportation. Rinsate blanks will be prepared using distilled deionized analyte-free water or solvent, whichever is appropriate to the chemical(s) of interest (i.e., solvent used in equipment decontamination process), as provided by the laboratories or obtained commercially (e.g., high performance liquid chromatography water).

6.7.1.2 Field Duplicates

Field duplicates are prepared in the field to assess the precision of the sampling and analytical procedures. Field duplicates of solid matrices (sediment) are prepared by homogenizing or mixing a double portion of a sample and placing equal aliquots of the homogenate in two sets of glassware.

Homogenizing is inappropriate for the analyses of volatile organics. In such cases, two grab samples will be taken from the sampling location. A grab sample is a sample that is taken at one time.

Field duplicates will be submitted blind to the laboratory. The true identity will be thoroughly documented in the field notes. This documentation is not submitted to the laboratory. Field duplicates should be collected at the frequency specified in Table 5-12. If the results of field duplicates differ dramatically (RPD > 100%), an analytical problem may exist or the matrix is not homogeneous, and the data must be critically assessed.

6.7.1.3 Trip Blanks

Trip blanks are required when solid samples are analyzed for volatile organics. The trip blank is water obtained from the analytical laboratory and carried with the field sample bottles during the sampling event. When the sampling event has ended, the trip blanks are labeled and shipped to laboratory along with representative field samples for volatile analyses only. Trip blanks will be processed at a frequency of one for each cooler shipped from field to laboratory which contains field samples for volatiles analyses.

6.7.2 Laboratory QA/QC Checks

Laboratory QA comes both from strict adherence to the QA/QC measures inherent in the analytical methods used, and from adherence to an overall laboratory QA program. The laboratory QA program should specify that procedures, both technical and administrative, be documented as SOPs, and disseminated to appropriate laboratory personnel. The QA program should also detail the mechanisms by which changes are incorporated into SOPs and the means by which revised SOPs reliably replace superseded copies. The program provides information on the analytical procedures conducted, documents that they were conducted according to sound scientific principles, and provides for systematic validation of analytical results. The QA program includes systematic monitoring of laboratory performance so that corrective actions can be taken as needed. The QA program also details the proper procedures for recording and archiving data. It is the responsibility of the Laboratory QA Manager and Laboratory Director to implement the QA program and evaluate its effectiveness.

Laboratory QA procedures will be followed to document proper sample handling and tracking of analytical accuracy and precision. Proper sample handling procedures will be documented using logbooks for sample storage and transport as outlined in the laboratory SOPs. Accuracy will be evaluated using analyses of blanks, surrogate spikes, matrix spikes, and LCSs and precision will be evaluated using analysis of laboratory duplicates.

6.7.2.1 Laboratory Method Blanks

Laboratory method blanks are prepared from analyte-free (as defined in Section 6.7) reagents as demonstrated by laboratory analysis and carried through the identical preparation and analysis procedures as for samples submitted from the field for analysis. The purpose is to determine if potential sample contamination is arising as an artifact of laboratory procedures. Laboratory method blanks will be analyzed at the frequency specified in the method, but at a minimum of one for each analytical batch of samples. (A batch is defined as a group of up to 20 samples of the same matrix, prepared at the same time, using the same procedure.)

6.7.2.2 Laboratory Duplicates

Laboratory duplicates are two portions of a single homogeneous sample that are analyzed for the same parameter in order to determine the precision of the analytical system. The analytical laboratory will perform duplicate analyses for the metals and cyanide methods specified in Table 6-8. Laboratory duplicates will be analyzed at the frequency specified in the method, at a minimum frequency of one for each analytical batch of samples. (A batch is defined as a group of up to 20 samples, of the same matrix, prepared at the same time, using the same procedure.)

6.7.2.3 Surrogate Spikes

Surrogate spikes are added to samples to be analyzed for organic contaminants where specified in the analytical method. Surrogate compounds are compounds not expected to be found in environmental samples; however, they are chemically similar to several compounds analyzed in the method. In the SW-846 method protocols, there are six semivolatile surrogates and three volatile surrogates that are added at predesignated amounts for the appropriate analyses. Primary and alternate surrogate compounds are recommended for pesticide, Aroclor PCB, and herbicide analyses in the respective methods.

A %R for the surrogates is calculated concurrently with the analytes of interest. Since the sample characteristics will affect the %R, the %R is a measure of accuracy of the analytical method on each individual sample (laboratory QC acceptance criteria for surrogate recoveries are given in the individual methods and as noted throughout Section 6.6.1).

6.7.2.4 Matrix Spikes

MS/MSD samples are analyzed for organics, while a MS (only) and laboratory duplicate sample are analyzed for metals, cyanide, and other inorganics. Laboratory QC acceptance for MS/MSD samples are discussed throughout Section 6.6.1.

MS/MSD sample analyses for organic analyses and MS only analyses for metals and cyanide are used to evaluate the effect of the sample matrix on the accuracy of the laboratory method. Known concentrations of analytes are added to environmental samples; the MS, and in the case of organic analyses, MSD, are then processed through the entire analytical procedure and the recovery of the analytes is calculated. Results are expressed as %R of the known amount spiked.

For all organic analyses, MS/MSD %R values are further used to determine the precision of the analytical system. This determination is done by evaluating the RPD between the two %R values obtained for the MS/MSD pair.

MS/MSD or MS/Duplicate analyses will be performed at the method specified frequency. The analytical laboratory will perform MS/MSD or MS/Duplicate analyses where appropriate at a minimum frequency of one for each analytical batch of samples. (A batch is defined as a group of up to 20 samples, of the same matrix, prepared at the same time, using the same procedure.)

6.7.2.5 LCS

A clean laboratory matrix, which is spiked with a known amount of a standard (or standards), is defined as a LCS. The LCS results provide an indication of the accuracy of the laboratory's analysis on standard materials. The analytical laboratory will perform an LCS analysis representing each target analyte group at a minimum frequency of one for every analytical batch of samples. (A batch is defined as a group of up to 20 samples, of the same matrix, prepared at the same time, using the same procedure.)

6.7.2.6 Performance Evaluation (PE) Samples

Dioxin-specific PE samples (i.e., Standard Reference Materials [SRMs]) representing a solid sample matrix will be purchased from a commercial vendor. The PE samples will contain various target dioxin/furan isomers described herein at known and certified reference concentrations.

Two PE samples will be submitted blind to the laboratory prior to the start of each phase of the RI. One PE sample will contain known and certified concentrations of dioxin/furan isomers, while the other will be a certified blank material.

Results for the two PE samples will be supplied by the laboratory prior to field mobilization. PE sample concentrations reported by the laboratory will be compared to certified reference acceptance ranges supplied by the vendor. These evaluations will serve as a demonstration of the laboratory's ability to apply the specified analytical methodology to the solid sample matrix with defined and acceptable accuracy.

6.7.3 Laboratory QA/QC Documentation

QA/QC procedures followed in the laboratory will be documented through the use of logbooks and system audits. Logbooks will be provided for sample handling, instrument monitoring and calibration, preparation of standards, and receipt of chemicals and supplies. Out-of-compliance occasions will be logged by the Laboratory QA Manager, with corrective actions described and resolution of the out-of-compliance situation noted as to time, date, and effectiveness. Raw and reduced data necessary to evaluate analytical QA will be stored by the laboratory, in accordance with method SOPs and the laboratory's QA program. Project records will be available for on-site inspection during the course of the investigation. The laboratories will have SOPs in place for all phases of laboratory operations and analytical methods. The SOPs will be available for on-site review by non-laboratory personnel during the course of the investigation.

6.7.4 Re-Analysis of Samples

If re-analyses, as required by the analytical methodology SOPs, are required with exceptional frequency or in some systematic way, the QAC will be consulted by the laboratory to evaluate more appropriate analytical approaches to problematic samples.

6.8 Instrument/Equipment, Inspection, Maintenance and Calibration

Field Equipment inspection, maintenance, and calibration schedules will be developed for both field and laboratory instruments. A summary of the testing, inspection, maintenance, and calibration activities to be performed is presented below.

6.8.1 Field Instruments and Equipment

Prior to field sampling, field equipment will be inspected to verify it is operational. If the equipment is not operational, it will be serviced prior to use. Meters or batteries that require charging will be charged or fresh disposable batteries will be used. If instrument servicing is required, it is the responsibility of the appropriate field personnel to follow the maintenance schedule and arrange for prompt service. Table 6-9 presents an equipment maintenance log that will be used to track the inspection and maintenance of each piece of field equipment used during IWP activities.

Field instrumentation to be used in this study includes such items as:

- tide gage to measure water surface elevation;
- DGPS to determine horizontal location;
- fathometer to measure water depth; and
- photo-ionization detector to measure volatile organics.

Records of operation, maintenance, calibration, problems, and repairs will be maintained in a logbook as described in SOP No. 1 – Field Documentation. Field Supervisors will review equipment calibration and maintenance logs.

Field equipment returned from the Site will be inspected to confirm it is in working order. This inspection will be recorded in a logbook, as appropriate. It will be the obligation of the last user to record equipment problems in the logbook. Non-operational field equipment will be either repaired or replaced. Appropriate spare parts, batteries, and/or battery chargers will be made available for field instruments.

6.8.2 Laboratory Instruments and Equipment

Laboratory instrument and equipment maintenance procedures are provided in the laboratory's QA manuals and associated laboratory SOPs. Documentation will include details of observed problems, corrective measures, routine maintenance, and instrument repair, including information regarding the repair and the individual who performed the repair.

Preventive maintenance of laboratory equipment will follow the guidelines recommended by the manufacturer. A malfunctioning instrument will be repaired immediately by in-house staff or through a service call from the manufacturer.

Maintenance schedules for laboratory equipment will adhere to the manufacturer's recommendations. Records reflect the complete history of each instrument and specify the time frame for future maintenance. Major repairs or maintenance procedures will be performed through service contracts with the manufacturer or qualified contractors. At a minimum, paperwork associated with service calls and preventive maintenance calls will be kept on file by the laboratory.

The laboratory analysts are responsible for the routine maintenance of instruments used in a particular laboratory. Routine preventative maintenance carried out will be logged in appropriate logbooks. The frequency of routine maintenance will be dictated by the nature of samples being analyzed, the requirements of the method used, and the judgment of the analysts and department managers.

Major instruments will be backed up by comparable (if not equivalent) instrument systems to avoid unscheduled downtime. An inventory of spare parts will also be available to minimize equipment/instrument downtime.

6.8.3 Field Equipment Calibration

Field equipment will be calibrated in accordance with the manufacturer’s operating manuals or as specified in the SOPs. Table 6-10 presents a calibration schedule for field equipment. Field instruments will be used by experienced operators familiar with field procedures and manufacturer's instructions. The general calibration procedures will conform to manufacturer's standard instructions.

Calibration provides confidence that the equipment is functioning within the allowable tolerances established by the manufacturer and required by the project. Calibration data will be maintained by the Field Supervisor in a logbook, and will be subject to audit by the QAC. Copies of instrument manuals will be maintained at the Site as necessary for reference.

6.9 Inspection/Acceptance of Supplies and Consumables

Standards, solvents, and reagents will be logged and dated upon receipt. Standards will be discarded (according to SOP 9 – Management and Disposal of Residuals) after the maximum recommended holding time has expired or when analysis indicates that the standard has degraded beyond acceptable tolerances. Solvents and reagents will be used on a revolving "first in, first out" basis to minimize storage time and the potential for degradation and/or contamination.

Each lot of solvents and reagents will be tested, through the use of method blanks, to assess the presence or absence of contaminants and interferents. If contamination is noted, confirmatory analyses will be performed. If the contamination is confirmed, the lot will be discarded.

6.10 Non-Direct Measurements

Data produced from previous investigations at Newark Bay are provided in RIWP Volume 1 (Tierra, 2004), and were used to assist in designing the Phase I SI Program. The quality and usability of this historical data are addressed as part of Volume 1, and will also be discussed as part of the Newark Bay RI Report.

6.11 Data Management

Data management is crucial in the organization of the project data and information. Field data including weather conditions, air temperature, field personnel, field equipment, field equipment calibration, sample collection, and sample coordinates will be recorded daily in the logbook. Field documentation will be completed as per SOP No.1 – Field Documentation. As appropriate, field data will be transferred to electronic form and maintained in a project database.

Analytical results will be obtained from laboratories in electronic and hard copy format. Upon receipt from the laboratory, these results will be validated as described in Section 8. Once validated, the electronic laboratory data will be placed in the project database. An internal check will be performed on data transfer to optimize accuracy. The database will be maintained in a central location. Alterations to the database will be checked accordingly. Electronic data obtained through this Phase I SI Program will be made available to USEPA upon request as per the AOC.

The data collection and documentation activities (both laboratory- and field-related) specified in this IWP are intended to meet the general requirements established for the NBmis (Newark Bay management information system) database. The specific requirements of this system will be confirmed with USEPA prior to initiating field activities to ensure that the data and information collected under this IWP are consistent with those requirements.

7. Assessment and Oversight

Project operations will be continually reviewed to assess data quality through the implementation of performance audits and systems audits. The QA program operates independently of the overall project structure to provide an effective external check and independent peer review of work plans, reports, and calculations.

7.1 Performance Audits

Performance audits are used to quantitatively assess the accuracy of measured data through the use of performance evaluation and blind check samples. Such performance audits (PE samples [dioxin only] and field duplicate evaluations) are described in section 6.6 of the IWP. The need for additional performance audits will be evaluated by the QAO with due consideration given to the recommendations of the FC.

7.2 Systems Audits

Systems audits generally consist of an external review of the field and laboratory QA systems and physical facilities for sampling, calibration, and measurement.. These systems audits will be performed by the QAC or other designee of the QAO. USEPA may also perform systems audits at their discretion.

Systems audits shall be conducted to determine whether:

- the QA program has been documented in accordance with specified requirements;
- the documented QA program has been implemented; and
- instances of nonconformance have been identified and corrective action(s) have been implemented.

The QAO, in consultation with the QAC, will be responsible for initiating systems audits and monitoring the audit implementation. The QAC or the QAO's designee, hereafter referred to as the Auditor, will conduct field and laboratory audits to coincide with appropriate activities on this project, as described in this section. At least one onsite field audit will be conducted during sample collection activities (in this case for the Phase I SI Program) covering each individual program task. Laboratory systems audits will be completed in advance of using a given laboratory. Laboratory audits conducted for work performed by Tierra in the past may be considered to meet the advance audit requirements.

The systems audit will include review of project files, document tracking processes, and individuals performing field work and report preparation. Systems audits may review the total data generation process, which includes onsite review of the field and laboratory operational systems; physical facilities for sample processing, sample collection, and tracking; equipment calibrations; the procedures field and laboratory staff use to generate acceptable data; and project files.

The FC, and if appropriate, the audited entity (e.g., Field Task Leader, Laboratory Supervisor) will be notified by the QAO (or the Auditor) of an audit within a reasonable time before the audit is performed. This notification will include information such as the general scope and schedule of the audit and the name of the Audit Team Leader.

7.2.1 Field Activities Audits

Audits of field activities will be scheduled at various times to evaluate the execution of sample identification, sample control, chain of custody procedures, field documentation, and sampling operations. The evaluation will be based on compliance with this document, SOPs, and HASCP requirements. At least one field audit of each individual program task will be performed during sample collection activities. Additional audits may be conducted at the discretion of the QAO in consultation with the QAC and/or FC.

The field audit will be conducted by a reviewer who is familiar with the technical and procedural requirements of field sampling and with the applicable work plan requirements. The Auditor will maintain a record of the evaluation by preparing written documentation of the audit. Following the audit, preliminary results will be reviewed with the person in charge of the sampling. The Auditor will also prepare an audit report containing the results of the evaluation and recommendations for corrective actions.

The following are specific areas that may be evaluated in a given field audit:

- sample labels;
- chain of custody;
- sampling operations; and
- document control.

The Auditor will examine a selected number of sample labels for completeness and accuracy. The Auditor will determine if the requisite information as specified in SOP No. 2 – Containers, Preservation, Handling and Tracking of Samples for Analysis is included on the label.

The Auditor will select a number of the chain of custody records at random to be audited in the field. The chain of custody records will be reviewed to determine if 1) the sample number, date, and time correspond to the sample label; 2) the parameters to be analyzed have been properly identified; and 3) custody transfers have been documented and the date and time of transfer have been recorded. The Auditor will also evaluate if samples have been kept in custody at all times and have been properly and securely stored.

Logbooks will be reviewed during the field audits to determine if entries are dated and signed. The project number, site name, name of the person responsible for the book, and the date the book was received should be recorded on the cover. Pertinent information will be recorded in these logbooks from the time each individual is assigned to the project until the project is completed, the book is full, or the responsibility for the logbook is transferred to another individual. The Auditor will review logbooks to determine field staff adherence to these procedures.

Field observations and measurements will be recorded as described in SOP No. 1 – Field Documentation with pertinent information necessary to explain and reconstruct sampling operations. Each page will be dated and signed or initialed by individuals making entries on that page. The field team on duty will be responsible for ensuring that logbooks are available during monitoring activities and that they are safely stored at the end of each day's sampling activities, and after the final day of field activities, to maintain security. Lost or damaged logbooks will be reported to the QAO.

The Auditor will review sampling operations to determine if they are performed as stated in this document. The Auditor will evaluate whether the samples are in proper containers and are properly preserved. The Auditor also will evaluate whether the required field observations and QA checks have been performed and documented as directed.

The document control audit will consist of checking each document for accountability. Documents used for field activities will be checked against the list of field documents required as part of this IWP. Written explanations will be provided for documents that are unaccounted for.

The documents will be examined to determine if required items such as signatures, dates, and project codes are included. The Auditor will examine controlled documents and evaluate whether they have been handled and stored in the proper manner.

Original records generated for audits shall be retained within the Newark Bay Central Project File (Section 5.4.2). Records shall include audit reports, written replies, the record of completion of corrective actions, and documents associated with the conduct of audits, which support audit findings and corrective actions as appropriate. Field corrective actions are discussed in Section 7.3.1.

7.2.2 Laboratory Audit(s)

An onsite laboratory evaluation helps discern whether the necessary QA/QC practices are employed by the laboratory in order to deliver a product of the expected quality. Laboratory audits will be performed in advance of using a given chemical testing laboratory. Audits of analytical chemistry laboratories conducted by Tierra in the past shall be considered to meet the advance audit requirement unless a period of inactivity greater than 2 years occurs. Inactivity is defined as a time frame during which a chemical testing laboratory has not analyzed samples for Tierra.

Laboratory audits shall include an evaluation of whether the following criteria are met:

- the organization and personnel are qualified to perform assigned tasks;
- adequate facilities and equipment are available;
- complete documentation, including chain of custody of samples and internal sample tracking measures are being implemented;
- required analytical methodologies are being used;
- adequate analytical or testing QC, calibration including reference samples, control charts, and documented corrective action measures, are being provided; and
- acceptable data handling, documentation techniques, and data review are being used.

Copies of relevant and current state certifications and performance evaluations for parameters of interest should be obtained from the laboratory and reviewed during the audit.

At the conclusion of the audit, the Auditor shall hold a post-audit conference with the Laboratory Manager, Laboratory Supervisor, or designated representative to present audit findings and clarify misunderstandings. Corrective actions or responses required shall be conducted in accordance with the provisions of Section 7.3.2.

7.2.3 Audit Finding Reports

An audit report will be prepared by the Auditor and signed by the QAO. The report will include the following:

- description of the audit scope;
- identification of the Audit Team;
- persons contacted during the pre-audit and post-audit activities;
- summary of audit results, including an evaluation statement regarding the effectiveness of the elements audited;
- details of each finding and program deficiency, identified and described in sufficient detail to ensure that corrective action can be effectively carried out; and
- recommendations for correcting deficiencies or improving the field or laboratory procedures.

The audit report shall be addressed to the FC with a copy to the QAO**.** A copy of the audit report will be distributed to the USEPA as part of the Newark Bay RI Report.

Original records generated for audits shall be retained within the Newark Bay Central Project File (Section 5.4.2). Records shall include audit reports, written replies, the record of completion of corrective actions, and documents associated with the conduct of audits that support audit findings and corrective actions, as appropriate.

7.3 Corrective Actions

Instances of nonconformance and issues requiring corrective action identified by the Auditor during performance audits, systems audits, or data evaluation activities will be communicated to the audited entity and the QAO. A corrective action is a documented change in field or laboratory procedure that is designed to bring the practice into compliance with the QA objectives. Typically, a corrective action is required because stated IWP procedures or SOPs are not being followed. However, a corrective action can also include changes that will improve or modify procedures presented in this IWP, if procedures are inadequate to provide guidance for unforeseen circumstances. The purpose of a corrective action is to ensure that data of known quality are generated, and that procedures followed are in accordance with this document.

7.3.1 Field Corrective Actions

Corrective action resulting from field audits, or other sources identifying the need for corrective action will require notification of the FC and QAO. The actions taken should be noted in the fieldbook and described on a corrective action form (CAF) similar to Figure 7-1, which is to be approved by the FC and the QAO. If corrective action does not solve the problem, appropriate personnel will be assigned to investigate and evaluate the cause of the problem. Once a corrective action is implemented, the effectiveness of the action will be verified.

The CAF will include a description of the deviation and the date(s) of the deviation, the reference to the affected section(s) of the project plans, and resolution of the deviation. The CAFs will be prepared and approved within five working days of the event. A CAF prepared for this project will be included in the QC summary submitted with the Newark Bay RI Report. The USEPA RPM will be informed of any corrective actions made during implementation of this RIWP.

Contingency plans or corrective actions may include, but are not limited to, the following actions:

- re-sampling of potentially affected samples;
- discarding potentially affected samples or data;
- accepting samples or data with an acknowledged level of uncertainty or error; and
- correcting or amending sampling or measurement procedures.

Data that are deemed unacceptable following the implementation of the contingency plan or corrective action will not be used for final data analysis.

The corrective actions described in this sub-section do not necessarily require SOP modifications. Should the need for significant SOP changes be identified, the FC will contact the USEPA RPM and request formal approval for such a change(s).

7.3.2 Laboratory Corrective Actions

Corrective action resulting from laboratory audits or other sources identifying the need for corrective action will be initiated by the Laboratory QA/QC Manager in consultation with the QAO or designee, documented on forms such as that in Figure 7-1, and approved by the FC and the QAC. Corrective actions identified by the laboratory will be reported to the QAC, QAO, and FC for review prior to implementation. If the corrective action requires a substantial modification, such proposed modification will be submitted to USEPA for approval. Corrective actions may include, but are not limited to, the following:

- correcting laboratory procedures;
- accepting data with an acknowledged level of uncertainty;
- recommending resampling and re-analysis.

Whenever corrective action is necessary to eliminate the cause of a non-conformance, as appropriate, the QAO or the FC will ensure that appropriate steps are followed. For example:

- the problem will be defined;
- responsibility for investigating the problem will be assigned and accepted;
- the cause of the problem will be investigated;
- a corrective action to eliminate the problem will be identified;
- responsibility for implementing the corrective action will be assigned and accepted;
- the effectiveness of the corrective action will be evaluated;
- substantive modification of the approved IWP shall be submitted in writing for USEPA approval; and
- the effectiveness of the corrective action will be verified.

7.3.3 Immediate Corrective Actions

Equipment or instrument malfunction will require immediate corrective action. Field and laboratory QC measures and QA plans are working tools used to identify appropriate immediate corrective actions to be taken when non-conformance to plans or QC limits are encountered. They provide the framework for uniform actions as part of normal operating procedures. Immediate corrective actions taken will be applied on a daily basis as necessary, and will be recorded in the logbooks.

8. Data Validation and Usability

The analytical data generated by the laboratory(ies) will be evaluated to assess specific precision, accuracy, representiveness, comparability, and completeness criteria as described in Section 5.2.2, of this document.

The validation results will be used to provide an evaluation of the overall laboratory performance based on the following data quality parameters:

- Precision of analysis through evaluation of matrix duplicate or MSD analytical results as specified in Section 5.2.2.1 of this IWP;

- Accuracy through evaluation of spike sample recoveries, LCS analyses, and surrogate spike recoveries as specified in Section 5.2.2.2 of this document;

- Representativeness through adherence to sampling procedures described in Section 5.2.2.4 of this IWP;

- Comparability through evaluation of sample-specific reporting limits, units of measure, and adherence to specified analytical methodologies as specified in Section 5.2.2.5 of this IWP; and

- Completeness through evaluation of the overall field completeness and the overall analytical completeness as specified in Section 5.2.2.3 of this IWP.

8.1 Verification and Validation Methods

The chemical and radiochemistry data generated by the laboratory(ies) will be checked for accuracy, precision, and completeness. The data verification and validation processes for this project will consist of two levels of review – data verification processes performed by the laboratory generating data prior to the laboratory report being issued, and independent data validation processes performed prior to final results being provided to data users.

8.1.1 Data Verification Methods

The first level of review, which may contain multiple sublevels, will be conducted by the analytical laboratory data reviewer. This individual (or individuals) has the initial responsibility for the correctness and completeness of the data. The laboratory data reviewer will evaluate the quality of the analytical data based on an established set of laboratory guidelines and this document.

The individual will review the data packages to confirm the following:

- sample preparation information is correct and complete;
- analysis information is correct and complete;
- the appropriate SOPs have been followed;
- analytical results are correct and complete and results are reported using proper units;
- QC samples are within established control limits;
- blanks are within appropriate QC limits;
- analytical results for QC sample spikes, sample duplicates, initial and continuous calibration verifications of standards and blanks, standard procedural blanks, LCSs, and ICP interference check samples are correct and complete;
- tabulation of reporting limits related to the sample are correct and complete;
- special sample preparation and analytical requirements have been met; and
- documentation is complete (anomalies in the preparation and analysis have been documented; holding times are documented).

The laboratory will perform the in-house analytical data verification steps under the direction of the laboratory data review supervisor. The laboratory is responsible for assessing data quality and advising the QAC of data rated "preliminary" or "unacceptable," or other notations that would caution the data user of possible unreliability. Data verification performed by the laboratory will be conducted as follows:

- Raw data produced by the laboratory analyst will be processed and reviewed for attainment of QC criteria as outlined in this IWP and/or established USEPA methods for overall reasonableness;

- The laboratory's data reviewer will check sample data entered manually for entry errors and will check data electronically uploaded from the instrument output into the software packages used for calculations and generation of report forms for transfer errors and decide whether sample re-analysis is required;

- The laboratory will review initial and continuing calibration data, calculation of response factors, surrogate and system monitoring compound recoveries, MS/MSD recoveries, sample spike recoveries, post-digestion spike recoveries, internal standard recoveries, LCS recoveries, and sample results; and

- Upon acceptance of the preliminary reports by the laboratory's data reviewer, the Laboratory QA/QC Manager or designee will review and approve the data packages prior to generation of the final reports.

The data verification steps will be documented, signed, and dated by the individuals responsible for each task.

8.1.2 Data Validation Methods

The second level of review is validation. Data validation will be performed by a designee of the QAO, whose function is to provide an independent review of the data package. This process will include a review of project data quality measurement parameters (Section 5.2.2), in addition to the completion of specific data validation procedures described below.

The QA/QC methodologies specified in this IWP are based on those set forth in SW-846. This document was prepared taking into consideration the *USEPA Region 2 CERCLA Quality Assurance Manual*, (USEPA, 1989) which recommends the use of SOPs for data validation.

The specific USEPA Region 2 SOPs listed below will be used for validation of sample data and laboratory performance criteria for the pesticides, PCDD/PCDFs, volatile organics, semivolatile organics, chlorinated herbicides, Aroclor PCBs, metals (ICP and Cold Vapor Atomic Adsorption) and cyanide. Copies of the SOPs are included in Appendix D of this IWP.

For Aroclor PCB and pesticide data:

- SOP for Validating Pesticide/PCB compounds by SW-846 Method 8081/8082, SOP No. HW23, Revision 1.0, May 2002.

For semivolatile organics data:

- SOP for Validating Semivolatile Organic Compounds by SW-846, Method 8270C, SOP No. HW-22, Revision 2, June 2001.

For chlorinated herbicide data:

- SOP for Validating Chlorinated Herbicides by Gas Chromatography, Method 8150A, SOP No. HW-17, Revision 1.3, November 1994.

For metals and cyanide data:

- Evaluation of Metals Data for the Contract Laboratory Program, SOP No. HW-2, Revision 11, 1992.

For dioxin and furan Isomer data:

- SOP for Validating Tetra through Octa Chlorinated Dioxins and Furans by Isotope Dilution (HRGC/HRMS), Method 1613A, SOP No. HW-25, Revision 2, September 1999.

For volatile organics data:

- SOP for Validating Volatile Organic Compounds by SW-846, Method 8260B, SOP No. HW-24, Revision 1, June 1999.

USEPA Region 2 does not provide validation SOPs for radiochemistry parameters, PCB congeners, TEPH, Organotins, TOC and other non-SW-846 analyses. Therefore, validation and qualification of the laboratory performance criteria are specified in data validation SOPs prepared for this project (Appendix D).

Special consideration will be given to the validation of metals and cyanide data. The metals and cyanide analysis validation SOP referenced in the USEPA Region 2 manual is specifically designed for the QA/QC methodologies and analytical methods specified in the USEPA CLP Statements of Work, rather than those in SW-846. Therefore, the QC limits specified in the analytical methods will replace the control limits in the SOP. If there is a QC sample or measure specified in an SOP that is not required when using the analytical methods, the response by the validator in completing the SOP checklist will be "not applicable." If a validation question in the USEPA Region 2 SOP checklist refers to similar processes (in CLP versus the analytical method) with somewhat differing protocols, such as calibration requirements, the validation question will be evaluated and answered with respect to the analytical method requirements in place of responding "not applicable."

Typical sediment samples collected during previous investigations in the Passaic River (a tributary to Newark Bay) have been found to contain average moisture content of approximately 65%. Based on this fact, moisture contents of samples collected under this IWP are expected to be 50% or greater. When sediment samples are found to contain between 50% and 90% moisture, and no other data quality issues exist that require data qualification, an "M" data qualifier will be added. The "M" qualifier is intended to replace the "J" sample qualification described in the USEPA Region 2 data validation SOPs referenced above regarding solid sample analyses where moisture contents are between 50% and 90%.

Upon completion of data validation, the data packages, completed assessment checklists, telephone record log(s), data summary sheets, data assessment narratives, and data assessment checklists shall be placed in the Newark Bay Central Project File (Section 5.4.2).

As part of the data validation process, the following validation qualifiers and their meanings will be used.

- 'U' Non-detect – The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
- 'J' Estimated value – The analyte was positively identified, but the associated numerical value is the approximate concentration of the analyte in the sample.
- 'NJ' The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
- 'UJ' Estimated non-detect – The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
- 'R' The sample results are rejected – Due to significant QA/QC problems, the analysis is invalid and provides no information as to whether the analyte is present or not. Once the data are flagged with an 'R', further review or consideration is unnecessary.

‘M’ The analytical result reported was obtained from a sediment sample found to contain between 50% and 90% moisture and had no other data qualifiers added during the data validation process.

If no determination of the overall bias of a result qualified as estimated can be made, the result will be qualified with a ‘J.’ If the data reviewer can determine the overall bias for sample data qualified as estimated, the data reviewer will qualify the sample result as either an estimated minimum value (JL) or an estimated maximum value (JH). The JL qualifier can also be applied to non-detect results. In addition, the ‘D’ qualifier can be added to the ‘J,’ ‘JL,’ ‘JH,’ or ‘NJ’ qualifiers to indicate that the reported result is from a diluted analysis.

One hundred percent of the data on the summary forms for each data package will be checked back to the raw data for potential calculation errors, transcription errors, and data transfer errors. If the initial validation efforts indicate that no significant problems are being encountered with respect to the laboratory performance criteria for a given laboratory, it may be requested of USEPA that review of these criteria on the remaining data not be required.

8.2 Reconciliation with User Requirements

Project operations will be continually reviewed to assess data quality and adherence to the requirements outlined in this document. This will be accomplished using the mechanisms previously described in Section 7, including performance audits, systems audits, data verification, data validation, and professional judgment The focus of these audits and assessments is to determine whether the IWP DUOs (Section 4.1) and DQOs (Section 5.2.1) are being met, or that appropriate corrective actions are implemented to correct noncompliant situations. Each of the monitoring steps will be carefully documented so that the data user can consider assessment findings and data qualifications when using the information for decision-making purposes.

Upon completion of data acquisition tasks, a thorough summation of data quality measurement parameters (Section 5.2.2) will be prepared based on the actual outcome of each parameter in the sampling program. Additionally, specific calculations will be presented describing achieved percent field completeness, as well as percent analytical completeness. Summarized data quality parameter outcomes, as well as the documentation of monitoring steps used during data generation activities, will be employed by the data user to reconcile results obtained with user requirements.

9. Other RI Tasks/Deliverables

In addition to the RI-related activities presented in Section 4 of this IWP, the AOC identifies several other tasks/deliverables that pertain to the RI process, including development of an RI Report and development/implementation of a Community Relations Plan. Each is discussed further below.

9.1 RI Report

Data collected as part of the Newark Bay RI process (including RI Goals 1 through 3) will be presented in an RI Report. As per Section E.2 of the SOW, the Newark Bay RI Report will (at a minimum) consist of the following sections:

- introduction, including purpose and Site background;
- description of the Newark Bay Study Area investigation;
- description of the Newark Bay Study Area physical characteristics;
- presentation of the chemical characteristics of water, sediment, and biota, including nature and extent of contamination, and contaminant fate and transport (including historical and RI data);
- summary and conclusions; and
- appendices, including technical memoranda on field activities, analytical data, and QA/QC evaluation results.

The Newark Bay RI Report will be prepared utilizing information contained in *Guidance for Conducting Remedial Investigation and Feasibility Studies under CERCLA* (USEPA, 1988).

9.2 Community Relations

As indicated in Section D of the SOW, USEPA will lead the development and implementation of a Community Relations Plan. Although USEPA will manage this effort, Tierra will provide assistance, as necessary, during the outreach process, which could include such activities as providing information regarding Newark Bay's history, participating in public meetings, or preparing fact sheets for distribution to the general public. Tierra's involvement (and the extent of such involvement) will be at the discretion of USEPA, and will be outlined in the above-referenced Community Relations Plan.

10. Schedule

This section presents scheduling information related to the planning and implementation of the Newark Bay RI in accordance with the AOC. For this discussion, the schedule is presented in two formats; the first (Table 10-1) lists the RI-related reports or plans that are mandated under the AOC. The second format (Figure 10-1) illustrates the estimated durations and relationships for those work tasks needed to implement the activities contained in this IWP.

Each schedule format is discussed individually below.

10.1 Schedule for AOC-Required RI Reports/Plans

Following is the list of deliverables mandated by the SOW for the Newark Bay Study Area:

- RIWP (including Inventory and Overview Report of Historical Data, IWP, SAP, SMP, QAPP, and HASCP);
- RI Report; and
- FSWP.

Table 10-1 includes these same reports/plans, and also provides the AOC-specified elapsed time (for the RIWP and FSWP) from prerequisite events in calendar days, within which each report or plan will be completed. As reflected in Table 10-1, it is estimated that the RI Report will take up to one year to complete following data validation/assessment associated with the last RI Program to be implemented.

10.2 Estimated IWP Project Schedule

The estimated schedule for implementing this IWP is displayed in Figure 10-1, and is based on the sequencing of the major events necessary for its completion. The major items included on Figure 10-1 include:

- submission of the RIWP;
- completion of the Phase I SI Program;
- submission of the Phase II SI Work Plan (i.e., RIWP Addendum);
- completion of the Source Identification Program; and
- submission of the Source Sampling Work Plan (i.e. RIWP Addendum).

In general, the schedule includes an estimate of 60 days for USEPA's review of each plan or report requiring approval, 30 days for revisions in response to USEPA's comments, and 14 days for USEPA's review of plans and reports revised in response to USEPA's comments.

In consideration of winter weather conditions typically encountered in the New York/New Jersey region, Tierra does not endorse the implementation of water-based activities between mid-December and early March. During this period, the chances of encountering inclement weather are high, which in turn can cause extremely unsafe boating situations (e.g., ice formation on deck, capsizing potential, etc). As such, Tierra will not normally schedule such work activities during the aforementioned period.

As shown on Figure 10-1, the start and/or duration of several events could not be estimated. Specifically, timing of the following activities cannot be determined at this time since the associated scopes of work have not yet been developed:

- Phase II SI Program - can not be scheduled until completion of Phase I
- Source Sampling Program - the AOC requires that the LPRRP and Newark Bay CSO Programs be conducted in a consistent manner. Since the LPRRP sampling design is still under development, the timing and scope of a Newark Bay CSO collection program (associated with the Source Sampling Program) is undetermined.
- Modeling Plan/Field Work – pending USEPA work plan
- Risk Assessment Plan/Field Work – pending USEPA work plan
- Feasibility Study Work Plan - the AOC requires that an FS WP be submitted 90 days following approval of the RIWP, and, according to the AOC, will include a schedule for the performance of the FS-related tasks.

Because the RI Report cannot be completed until after validation and assessment of data collected from the final RI Program, its start date and duration are not portrayed in Figure 10-1.

Future RI work plans (or RIWP addenda) to address other goals in the SOW, or to address data gaps that are identified during performance of this work, will contain a revised schedule for USEPA review and approval.

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